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USSR Report

AGRICULTURE

No. 1270



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MAJOR CROP PROGRESS AND WEATHER REPORTING

BRIEFS

SNOW RETENTION--Alma-Ata--The farmers of Kazakhstan are proceeding with snow retention at a rapid pace. In the northern oblasts of the republic early winter brought little snow and frosts fluctuated with long thaws. Links of machine operators brought their units into the fields after the first abundant snowfall. Virgin-land farmers know that almost half of the productive moisture in the region that is necessary for the development of crops is obtained from snow. The higher the snow in the fields the more grain in granaries. Setting the pace in socialist competition are the farmers of Severo-Kazakhstanskaya Oblast, who have cut snow windrows on over 2 million hectares. Following the advice of scientists at the All-Union Scientific-Research Institute of Grain they are plowing snow according to topography and the direction of the prevailing winds. Snow barriers prevent the flow of water into crevices, ravines and rivers. In Tselinogradskaya and Karagandinskaya Oblasts rural efficiency experts have developed an unusual attachment enabling machinists to increase the amount of snow collected by 1.5-2 times. Road clearing trucks are also being used successfully. The work is performed primarily by the large-group method; many detachments have moved toward the independent system of wage payments. As a result the unit output has increased noticeably. Thus, the machine operators of the Druzhba Sovkhoz of Kokchetavskaya Oblast and the Suvorovskiy of Tselinogradskaya Oblast surpass shift norms by 1.5-2 times. The farmers of Kazakhstan have pledged to produce 27-28 million tons of grain this year and to overfulfill the plan for its sale to the state. [Text] [Moscow TRUD in Russian 28 Jan 81 p 1] 8228

EARLY SOWING--Karshi, Kashkadar'inskaya Oblast--Yesterday sowing units moved into the fields of Kashkadar'inskaya Oblast, the granary of Uzbekistan. Sowing began unusually early. Farmers, having completed the repair of equipment, the preparation of seed and the removal of salt from plowland ahead of schedule, are trying to make use of the good weather. The weather is amazing, with sunny and clear days. It is time to sow. On the first day the machine operators of the Sovkhoz imeni Engel's, the largest grain-farming enterprise in the oblast, put seed into the ground on over 50 hectares, with 500 remaining. It is planned to complete this work in 1 week. [Text] [Moscow TRUD in Russian 28 Jan 81 p 1] 8228

FERTILIZERS IN FIELDS--Vilnius--Over 1,000 mechanized links from the kolkhozes and sovkhoses of Lithuania have begun the mass application of organic fertilizer in the fields allocated for intertilled crops. According to cartograms developed by rayon agrochemical centers they will be applying an average of 12-15 tons of compost per hectare of plowland. The republic's farms have planned to apply over 1 million tons of organic fertilizer for the new harvest. [Text] [Moscow TRUD in Russian 3 Feb 81 p 1] 8228

SOWING MATERIAL--Tambov--The preparation of sowing material is being completed by the grain farmers of Uvarovskiy, Rzhaksinskiy and Mordovskiy Rayons of the oblast. [Excerpt] [Moscow TRUD in Russian 3 Feb 81 p 1] 8228

SPRING PREPARATIONS--Will this be an early spring? It is hard to answer this question with certainty. But the enterprises of Uzbekistan are preparing for early field work and early sowing. This is proper since a real winter has not yet come to the steppes and valleys of the republic. The enterprises of Kashkadar'inskaya and other southern oblasts of the republic have already begun sowing early grains. In our Central Asiatic zone such winters are possible. In order to meet the unexpected, complete and accelerated completion of all pre-sowing operations is required. Under such conditions a great deal depends on the thought-out actions of grain farmers and on their purposeful work. In the republic as a whole preparatory work is proceeding ahead of last year's schedule. This has been encouraged by the early completion of harvesting operations in the fall. Fall plowing was completed on all fields on a very good schedule. Two-thirds of the fields were plowed with double-tiered plows with the simultaneous cultivation of the sublayer. Land that did not require desalination received mineral and organic fertilizers. In comparison with last year more chemicals are being used to combat perennial weeds. Thousands of long-based levels are carefully leveling cotton plantations. The scale of this work in comparison with last year has increased. Over 1 million hectares of saline lands have been desalinated already. Over 1.2 million hectares of plowland have received reserve irrigation, which is continuing everywhere. Farms are applying organic fertilizers to the fields. Millions of tons are being applied in the fields of the Ferganskaya Valley and the Zerafshanskaya and Surkhan-Sherabadskaya steppes. Over 90 percent of the irrigation equipment is ready for operations. [Excerpts] [Moscow SEL'SKAYA ZHIZN' in Russian 31 Jan 81 p 1] 8228

PROGRESSIVE COTTON FARMING--As usual, special attention is being focused on the development of technical progress in cotton farming. In the spring of the first year of the new five-year plan progressive technology will be utilized on large areas. This technology was tested for many years in the enterprises of Tashkent'skaya Oblast. Over 0.5 million hectares have been allocated for precise sowing using bare seed. Over 400,000 hectares will be sown in rows of cotton. All of the cotton will be sown with the simultaneous application of nitrogen and phosphorus fertilizers, and on an area of over 1 million hectares with the application of herbicides using the strip method. This year's sowing campaign will be characterized by the use of highly conditioned cotton seed. The republic's cotton-cleaning industry in general deals adequately with the preparation of sowing material but just as last year there are some lags in the production of bare seed for precise sowing. An important innovation is the expansion of the area for cultivating new, highly productive and more wilt-resistant varieties of cotton such as Tashkent-6, Samarkand-2, Samarkand-3, Uychi-2, Andizhan-2, Ashkhabad-25, Termez-14 and others. They will occupy about 500,000 hectares, or double last year's area. At the same time the area in early variety S-4727 will increase. Facts indicate that after the all-union, republic and oblast agronomic conferences the participation of specialists and their role in the organization of the production process have increased noticeably. [Excerpts] [Moscow SEL'SKAYA ZHIZN' in Russian 31 Jan 81 p 1] 8228

CHANGES IN UZBEKISTAN--At the same time there have been cases of passivity in the agronomic service in some enterprises of Dzhizakskaya and Syrdar'inskaya Oblasts. The ministry and oblast and rayon production administrations of agriculture are taking practical measures to improve agronomic work in all enterprises. This spring there will be important changes in all branches of farming. On an area of 200,000 hectares industrial technology will be utilized to cultivate corn for grain. Specialized brigades have already been enlarged and large, new corn-farming departments and sections have been created. Highly conditioned seed has been prepared and sowing technology has been brought to order. Most collectives have joined in competition to produce 80-100 quintals of grain per hectare of corn. The masters of vegetable plantations will have an important problem to solve. In addition to the future expansion of production of vegetables and melon crops they must increase the planting of potatoes by a factor of over two. Uzbek vegetable farmers will increase the cultivation of early and superearly products. According to regular calendar schedules the republic's farmers begin sowing operations for grains, corn, alfalfa and vegetables in mid-February. We plan to enter the fields by this date this year as well. The rural workers of Uzbekistan are striving to honor the 26th congress of their dear communist party through shock labor, by completing spring sowing on a shorter schedule and on a high agrotechnical level, and by creating a firm foundation for large yields of cotton, grains, feed and other crops. [Excerpts] [Moscow SEL'SKAYA ZHIZN' in Russian 31 Jan 81 p 1] 8228

ORGANIC FERTILIZER FOR FIELDS--Novosibirsk, 30 Jan 81--The oblast's farmers are actively preparing for spring during the first year of the new five-year plan. A great deal of attention is being given to moving local fertilizers into the fields. For this year's harvest over 6 million tons of organic fertilizer have already been readied, 1.5 million tons more than last year. The machine operators of Chulymskiy, Suzunskiy, Kupinskiy, Kochenevskiy and many other rayons have significantly overfulfilled their goals. The rayon association Sel'khozkhimiya [Agricultural chemical association] has been a big help to field workers in supplying organic fertilizer. In Dovolenskiy Rayon the collective of machine operators, headed by I. V. Paul, moved 86,000 tons of humus into the fields in comparison with the planned 60,000 tons. The quotas for the subdivisions of Sel'khozkhimiya have been overfulfilled in Ordynskiy, Tatarskiy, Baganskiy and other rayons of the oblast. [Text] [Moscow SEL'SKAYA ZHIZN' in Russian 31 Jan 81 p 1] 8228

STRONG GRAIN--Krasnodar, 31 Jan 81--The grain farmers of the Kuban' today pledged that 90 percent of the wheat they would sell to the state would be strong and valuable wheat. With this goal in mind all the necessary agrotechnical methods are being carefully carried out. A survey of crops has been completed to determine the condition of winter crops. Top-dressing using land methods and agricultural aviation will continue, and the struggle to combat crop pests will continue. This work is proceeding in an organized manner in Timashevskiy, Kanevskiy, Korenovskiy, Ust'-Labinskiy, Yeyskiy and other rayons, where workers have decided that all the wheat they sell will be up to strong and valuable standards for grain. [Text] [Moscow SEL'SKAYA ZHIZN' in Russian 31 Jan 81 p 1] 8228

SEED MANAGEMENT---Krasnodar, 31 Jan 81--Having decided to produce 35-36 quintals of grain per hectare this year, Kuban' farmers are giving special attention to the preparation of seed. Conditioned sowing material has been prepared for the entire area in spring crops. About three-fourths of the material corresponds to first class standards, and in the enterprises of Timashevskiy, Anapskiy, Tikhoretskiy, Gul'kevichskiy, Ust'-Labinskiy and several other rayons all of the seed is first class. [Text] [Moscow SEL'SKAYA ZHIZN' in Russian 1 Feb 81 p 1] 8228

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DAIRY INDUSTRY TASKS FOR FIRST YEAR OF ELEVENTH FIVE-YEAR PLAN

Moscow MOLOCHNAYA PROMYSHLENNOST' in Russian No 1, Jan 81 pp 1-4

[Article: "Tasks of Dairy Industry for First Year of Eleventh Five-Year Plan"]

[Text] During the 1980's, work must be completed on converting the economy over to intensive development and labor productivity must be raised sharply. An indispensable condition for achieving production successes continues to be that of improving the level of economic work and instilling a business-like attitude, responsibility and initiative in the personnel.

The Soviet people have completed their Tenth Five-Year Plan and they are greeting the forthcoming 26th CPSU Congress with new labor achievements. The past five-year period was characterized by the achievement of new and considerable successes in the economic development of the entire national economy. It occupies an eminent place in the history of heroic accomplishments by the Soviet people. A great forward step has been taken in developing the national economy and in solving important and great social tasks.

During the October 1980 Plenum of the CC CPSU, a discussion took place on the draft plans for social development of the national economy and the country's budget for 1981.

The General Secretary of the CC CPSU and Chairman of the Presidium of the USSR Supreme Soviet, Comrade L.I. Brezhnev, delivered an important and impressive speech during the Plenum. This speech provided a thorough and comprehensive analysis of the results of the Tenth Five-Year Plan and the plans for the first year of the Eleventh Five-Year Plan and it revealed the methods to be employed for solving the new tasks.

The Plenum gave its entire and complete approval for the positions and arguments set forth in the speech by Comrade L.I. Brezhnev and it resolved to have them serve as the foundation for the work to be carried out by all of the party, soviet and economic organs and professional trade union and komsomol organizations, with regard to the fulfillment and over-fulfillment of the 1981 plan and the more complete utilization of the intensive factors of economic development in the interest of improving the welfare of the people.

During the years of the Tenth Five-Year Plan, 329 billion more rubles were expended from the national income for improving the welfare of the people than were spent during the previous five-year period. Approximately 1.5 billion more rubles worth of capital investments were employed for housing construction than originally planned. The Soviet people were provided with roughly 0.5 billion square meters of housing space.

National income increased by 397 billion rubles, industrial output -- by 717 billion rubles and agricultural output -- by 50 billion rubles.

Six hundred and thirty five billion rubles were invested in the national economy and more than 1,200 large industrial enterprises were placed in operation.

The economy of the dairy industry was developed into a single national economic complex. The collectives of associations, enterprises and organizations achieved definite successes both in increasing the production of goods and improving their quality indicators, in implementing measures aimed at re-equipping the logistical base, in improving industrial control and in solving many social problems.

Despite the well known complexities and difficulties caused by the weather conditions, the total amount of milk delivered for industrial processing during the 5 years of the Tenth Five-Year Plan exceeded by 33 million tons the amount for the preceeding five-year period. The enterprises increased their output of all types of industrial products. The production of animal oil from state raw material resources increased by 820,000 tons (by 14 percent), whole milk products by 15.7 million tons (by 15 percent), fat cheese by 745,000 tons (by 29 percent), dry whole milk by 180,000 tons (by 20 percent), including mixtures for childrens' nourishment by 80,000 tons (by a factor of 2.9), dry skim milk by 730,000 tons (by twofold), including ZTsM [whole milk substitute] by 550,000 tons (by a factor of 3), canned milk by 665 million cans (by 11 percent and non-fat milk products by 4.5 million tons (by 65 percent). The branch's overall gross output increased by almost 7 billion rubles (by 12 percent).

The realization of the decree adopted by the CC CPSU and the USSR Council of Ministers on further development of the industrial production of childrens' food products made it possible to over-fulfill the established plans. Against a 1980 task calling for the production of 26,000 tons of dry milk mixtures for young children, 28,500 tons were actually produced and a task calling for the production of 200,000 tons of vitamin enriched milk -- 470,000 tons. However, many tasks of the five-year plan, owing to insufficient raw material resources, remained unfulfilled.

Owing to the use of ZTsM in agriculture, more than 6 million tons of milk were made available during the 1976-1980 period.

Important measures were carried out in industry aimed at raising work efficiency and quality, making it possible to increase output production by 7.3 percent, per unit of raw material processed, compared to the level for 1975.

During the five-year plan, the milk product resources were increased by almost 40 million tons, in a conversion for milk, as a result of having improved the

structure of production, increased the production of low fat products, placed reserves and resources in operation and also by having lowered the various types of losses. This made it possible to raise output sales by more than 1.5 billion rubles.

As a result of improving the operation of power engineering equipment and implementing other organizational measures at branch enterprises, considerable savings were realized in the use of fuel and thermal and electric power.

During the five-year plan, approximately 3,000 flow line-mechanized and automatic lines, assemblies and other items of highly productive equipment were introduced into operations throughout the industry. The branch's efficiency experts and inventors participated actively in the creation of machines, flow lines and automatic units. During the 1976-1980 period, approximately 60,000 rationalization proposals and inventions, representing an overall economic savings of 150 million rubles, were introduced into operations. A number of important measures were implemented aimed at improving organization, working conditions and the establishment of work norms, all of which made it possible to release approximately 25,000 individuals and realize an economic savings of approximately 40 million rubles.

During the 1976-1980 period, the branch's production costs for marketable output decreased by 2.2 percent, against a task calling for 1.6 percent for this period. This made it possible to raise the profitability of production operations. The profit from industrial activity increased by 22 percent during the five-year period.

A number of important measures were carried out during the 1976-1980 period aimed at raising the technical level of production through the accelerated introduction of completed scientific-research works and the creation and mastering of new equipment and advanced technology. The scientific-research organizations developed a technology for producing more than 40 new types of products, all of which meet the requirements being imposed. The scientific-research and design organizations of the branch, jointly with organizations of the machine building ministries, have created and recommended for series production more than 60 new types of equipment.

During the five-year plan, approximately 2 billion rubles worth of capital investments were expended for development of the production-technical base and more than 200 new enterprises were built, including 116 municipal dairy plants, 23 cheese-making installations and 32 enterprises for the production of whole milk substitute and dry skim milk. The production capabilities at 150 existing enterprises were expanded. The value of the fixed productive capital increased by 1.3 billion rubles during the years of the Tenth Five-Year Plan. Large municipal dairy plants were placed in operation in Saransk, Ryazan', Bryansk, Novgorod, Irkutsk, Brest, Vitebsk, Odessa and other cities. New production capabilities were placed in operation for producing almost 13,000 tons of whole milk products per shift, 140 tons of cheese and 395 tons of dry skim milk.

However, serious shortcomings are still being observed in the work being carried out by many industrial enterprises and by the branch on the whole. The chief such shortcoming -- weak organizational work on the part of the production collectives and all organs of control, with regard to increasing the raw material resources, raising the marketability of the milk and reducing its consumption to satisfy internal economic requirements in excess of the established norms and limits. There are still

many enterprises which have not achieved complete or efficient utilization of the principal or secondary raw materials and which are tolerating great raw material losses and also disruptions in the sanitary-hygienic regime for the processing of animal husbandry products. A considerable number of enterprises are operating in a non-rhythmic manner and they are not carrying out their planned tasks for the production of goods or in accordance with the technical-economic indicators.

The failure on the part of many enterprises to produce their planned variety of products and also the factor of considerable non-productive expenditures have affected the results of the economic activity. By no means has full use been made of the opportunities and reserves available for increasing the production of goods and improving their quality.

The operational results of industry in connection with carrying out the tasks aimed at raising labor productivity have been unsatisfactory. The principal cause -- serious shortcomings in the organization of labor, failure to adopt effective measures for the rational utilization of labor resources during the inter-seasonal period and slow solving of those problems associated with the mechanization and automation of production processes, particularly loading-unloading and transport-warehouse operations. In particular, this is typical of enterprises in the RSFSR, the Ukrainian SSR and the Belorussian SSR. The number of workers being maintained at many of these enterprises is in excess of the plan and the planned increases in production are not being achieved by means of improved labor productivity.

Many enterprises have not organized the work of realizing economies in the use of fuel and energy resources in a satisfactory manner and they are not fulfilling their established tasks.

The construction of a number of installations was carried out with great delays compared to the established schedules. Individual projects were accepted into operations with imperfections and capabilities newly introduced into operations are being mastered very slowly.

The highest rates of growth for the production of industrial goods during the Tenth Five-Year Plan were achieved by enterprises of Minmyasomolproms [meat and dairy industries] of the Uzbek SSR, Azerbaijan SSR, Armenian SSR, Georgian SSR and Soyuzkonservmoloko [All-Union Association of Enterprises of the Milk Canning Industry and Childrens' Food Products].

The October 1980 Session of the USSR Supreme Soviet examined in detail and adopted the law concerning the state plan for developing the national economy and the state budget for 1981 -- the first year of the Eleventh Five-Year Plan.

The 1981 plan calls for stable development of all branches of the national economy and consistent improvements in the standard of living of the Soviet people. A great amount of attention has been focused on improving the quality indicators and the efficiency of social production and mainly by means of intensive factors for improving the economy.

In the case of the dairy industry, the 1981 plan calls for a further increase in the production of all types of products, improvements in production efficiency,

strengthening of the logistical base and improvements in the technical level of production and in all of the quality indicators.

The state milk procurements for 1981 were defined in the amount of 60.6 million tons -- an increase of 7 percent over actual procurements in 1980. The fulfillment of this task requires a high level of organizational ability on the part of all of the industry's workers and the adoption of the most effective measures for intensifying procurements both in the public sector and on the farms of kolkhoz members and manual and office workers. The extensive dissemination of leading experience and the socialist competition must play an important role in the carrying out of this work. In conformity with the raw material resources, the production of cream butter at enterprises of the state industry must be increased during 1981 by 8 percent above the figure for 1980, whole milk products by 3 percent, cheese by 12 percent, SOM (dry skim milk) and ZTaM (substitute whole milk) by 24 percent, canned milk by 3 percent and dry whole milk by 6 percent.

The tasks of the 1981 plan are tense. But a number of factors serve to guarantee that they will be carried out successfully: the extensively deployed socialist competition to worthily prepare for the 26th CPSU Congress, measures undertaken to improve agriculture, the food program developed for the Eleventh Five-Year Plan and for the period up to 1990, which includes increasing the production of agricultural products, development of those branches of industry which service agriculture and measures to ensure the best preservation of the agricultural products and also their processing and delivery to the consumers.

The task is one of ensuring that the dairy industry workers make their own worthy contribution towards solving the food program and especially by ensuring a high level of efficiency and quality in the processing of the raw materials.

In this regard, during 1981 special attention must be given to implementing the decree of the CC CPSU and the USSR Council of Ministers concerning measures for improving the utilization of skim milk, buttermilk and whey.

In conformity with the increasing requirements of the population, the plan for 1981 calls for a high increase in the production of products in packaged and boxed form. Thus the production of whole milk and sour milk products in light packaging must be increased by 10 percent, cream by 18 percent, cottage cheese by 29 percent, sour cream by 13 percent and butter by 4 percent.

Great tasks must be carried out in 1981 in connection with raising the economic efficiency of industrial operations and this must be achieved through a more rational use of raw material, material, labor and financial resources and also by improving the quality of output and the use of fixed capital and production capabilities and also by reducing non-productive losses. As a result of implementing the measures called for in the plan, the savings to be realized from lowering the production costs for industrial output must amount to more than 50 million rubles.

A great and complicated task of the dairy industry in 1981 will be that of achieving planned growth in labor productivity. For the industry as a whole, it must be raised by almost 7 percent above the figure for 1980. In all of the enterprises and in all of the control organs, specific measures must be developed and

implemented aimed at improving the organization of production operations, introducing the brigade form of organization on an extensive scale and stimulating labor in such a manner so as to preclude the maintenance of an excess number of personnel, over-expenditures of the wage fund or a disruption in the ratio between growth in the wage fund and labor productivity.

In order to carry out the planned tasks for growth in labor productivity, great organizational work is required not only at the enterprises and organizations, but also in all organs of control. Objective concern must be displayed for such work commencing with the very first days of the new fiscal year.

The plans call for approximately 400 million rubles of capital investments to be used for developing the production-technical base of the dairy industry. Through the technical re-equipping, modernization and expansion of existing enterprises and the construction of new ones, the plans for 1981 call for the placing in operation of production capabilities for the production of whole milk products for 2,000 tons per shift, 53 tons of cheese and 91 tons of dry skim milk and substitute whole milk. The placing in operation of fixed productive capital was defined in the volume of 360 million rubles.

The plans call for the placing in operation of 24 municipal dairy plants, 14 cheese-making installations, 10 plants for whole milk substitute and dry skim milk and other installations. In conformity with the decree of the CC CPSU and the USSR Council of Ministers on "Improvements in Planning and Intensifying the Effect of the Economic Mechanism With Regard To Raising Production Efficiency and the Quality of Work," the concentration of capital investments at underway and carry-over projects was carried out. Approximately 70 percent of the resources allocated will be used for completing construction work on carry-over projects. The proportion of the increase in capabilities resulting from the carrying out of organizational-technical measures is being increased. The fulfillment of the 1981 plan for capital construction and the placing in operation of production capabilities is of great importance for ensuring planned growth in the production of goods during the Eleventh Five-Year Plan. The leaders of enterprises, associations and ministries must undertake all of the measures within their power to ensure fulfillment of the plan established for 1981. Existing shortcomings in the mastering of newly introduced capabilities must be eliminated and the planned indicators achieved within the established periods.

The Soviet people are preparing for the 26th CPSU Congress. The preparations for this historic event in the life of our country are being carried out in an atmosphere of great political and labor enthusiasm and an extensive national socialist competition. A program of work has also been launched at enterprises of the dairy industry for worthily preparing for the 26th CPSU Congress; the collectives are accepting counter plans and undertaking raised socialist obligations. Special attention is being given to raising production efficiency, accelerating technical progress and making more complete use of fixed capital and all available reserves.

The ahead-of-schedule fulfillment and over-fulfillment of the 1981 plan will be of great importance with regard to successfully carrying out those tasks assigned to the branch for the Eleventh Five-Year Plan by the 26th CPSU Congress.

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CLOSER TIES BETWEEN CONSUMER COOPERATIVES, PRIVATE FARMS URGED

Moscow EKONOMIKA SEL'SKOGO KHOZYAYSTVA in Russian No 12, Dec 80 pp 80-83

[Article by Yu. Popov: "The Role of Consumer Cooperatives in the Development of Private Subsidiary Farming"]

[Text] Public agricultural production is the basic source of satisfaction of the population's needs for agricultural produce. At the same time, private subsidiary farming plays a definite role in the formation of the country's food complex. In the report at the July (1978) Plenum of the CPSU Central Committee Comrade L. I. Brezhnev stressed that "we should also be concerned with the private farms of kol-khoz members, workers and employees. This is an important source of replenishment of food resources."

Under present conditions private subsidiary farming makes it possible to more efficiently utilize a significant part of the labor resources that for one reason or another are not utilized in the public sector of kolkhozes and sovkhoses. Owing to the seasonal nature of agricultural production private subsidiary farming serves as a reserve of employment for agricultural workers when the volume of work in the public sector (especially field work) declines sharply.

Private subsidiary farms of kolkhoz members and sovkhos workers and employees are closely connected with public farms. Kolkhozes and sovkhoses help their workers in the cultivation of soil on private plots, transport of fertilizers, supply of feed for their livestock and sale of agricultural produce. All this is advantageous for society, because in private subsidiary farming the socially necessary product is produced without additional capital investments on the part of the state. The decisions of the Communist Party and the Soviet Government have often pointed to the need for strengthening private subsidiary farming for the purpose of more fully satisfying the needs of the Soviet nation for food products and to some extent the needs of industry for processed raw materials.

Efficient help in the purchase of livestock and poultry and in the provision of fodder and mineral fertilizers has been given to the population in many of the country's regions recently. This work is well organized in the Lithuanian SSR, Gor'kovskaya and Kirovskaya oblasts, Aleyskiy, Pavlovskiy and Rubtsovskiy rayons in Altayskiy Kray and so forth. Throughout the country in 1977-1978 kolkhozes and sovkhoses sold 25.2 million young hogs to the owners of private subsidiary farms. This was 2.6 million head more than envisaged by the assignment. A total of 532 million head of young poultry were sold to the population in 1978. Purposeful

work on the development of private subsidiary farming leads to positive results. For example, in the country in 1977-1978 the number of large-horned cattle on workers' private subsidiary farms increased by 0.8 million head, of hogs, by 4.3 million head, of sheep and goats, by 1.2 million head and of poultry, by 46 million head and the production of meat in carcass weight rose by 0.3 million tons.

The decree of the CPSU Central Committee and the USSR Council of Ministers "On Additional Measures To Increase the Production of Coarse and Succulent Fodder in 1980 and To Improve Its Quality" permits the selling of up to 10 percent of the prepared hay and up to 20 percent of the straw to sovkhoz workers employed in fodder preparation and having domestic livestock in their private possession and the (free) distribution of up to 50 percent of the hay to workers employed in the manual mowing and preparation of hay on land unsuitable for the use of equipment for these purposes.

Consumer cooperatives provide active help in the development of private subsidiary farming. Procuring the surplus output of private subsidiary farms and organizing trade in orchard and garden implements and mechanization equipment, as well as in mineral fertilizers, they contribute to relieving rural dwellers of labor on the transportation and sale of their products, facilitating labor and increasing its productivity. Despite this the expenditures of manual labor on the population's subsidiary farms are extremely high. Cooperatives must improve the supply of implements of labor for the population.

The decisions of the 25th CPSU Congress set the task of organizing the mass production of improved orchard and garden tools and of other articles improving the way of life of the rural population. Now 338 enterprises of 58 ministries and departments deliver more than 300 varieties of implements of labor for private plots to trade organizations. Whereas previously local industry enterprises engaged in the production of implements of labor for private subsidiary farms, by the beginning of the 10th Five-Year Plan this production was concentrated primarily in heavy industry branches.

In 1979 RSFSR local industry enterprises alone produced orchard and garden tools worth 2.2 million rubles. This was 130 percent more than in 1978. They mastered the production of 13 new types of articles. In addition to rakes, hoes, watering cans and ordinary shovels, last year local industry manufactured orchard and garden shovels, rippers, weeders, manual cultivators and planting scoops. However, there is a shortage of implements as before. The point is that in some republics, that is, the Azerbaijan SSR, the Armenian SSR and so forth, orchard and garden implements are hardly produced. However, the provision of such implements for the population of these republics almost fully depends on their production in the country's other regions.

It should be noted that RSFSR local industry enterprises do not yet pay sufficient attention to the output of orchard and garden tools for children and adolescents. Incidentally, only two articles with the Badge of Quality are manufactured. Furthermore, these enterprises do not yet cope with the delivery of orchard and garden implements to the rural population according to the programs envisaged by the plan. The annual execution of the orders of trade organizations for various orchard and garden implements comprises only 90 percent.

Most articles designed to facilitate manual labor do not meet present technical requirements. Their appearance, quality and designs correspond to similar 15- to 20-year old articles. The protective and decorative coating, labeling and machining of joint welds especially evoke criticism. An optimum angle of inclination of the working part toward the handle is not ensured in most serially manufactured rakes and hoes, which increases the muscle load and lowers people's labor productivity by 10 to 17 percent. At present many complaints about the low quality of shovels, rakes, watering cans, sprayers and carts are received from the rural population.

Trade organizations should make stricter demands on industry to improve the quality of orchard and garden implements and to manufacture articles in quantities fully meeting the need of rural dwellers for them. In the next 5 years trade in orchard and garden implements will be developed at high rates. This will require the further development of a specialized trade network, as well as an organization of the sale of goods for horticulturists and gardeners through consumer complexes.

At present not much has been done to facilitate labor in private subsidiary farming, whereas constant concern for its mechanization is needed. Now there are only several types of small-scale mechanization equipment (household pumps, electric separators, butter churns and straw cutters). The rural population annually buys in cooperative stores 200,000 electric and 52,000 manual straw cutters and 320,000 separators. However, its need for small-size equipment is not met fully. The problem of the production of small-scale mechanization equipment for the cultivation of soil and care of plants on private plots and in collective gardens has not been solved thus far, although there is a great need for it.

The Minsk Tractor Plant manufactures a single-axle minitractor (of a 5 hp capacity). With this tractor it is possible to cultivate soil, to plant and harvest potatoes, to prepare hay and so forth. The tractor can be used successfully both on private plots of rural dwellers and in collective gardens. When this tractor is used for soil cultivation, labor productivity is 8 to 10 times as high as when manual implements are used.

A motor block with a set of trail-type and mounted implements making it possible to perform up to 20 types of operations in private subsidiary farming is very important for rural areas. Cooperative organizations have often asked machine building ministries to begin the manufacture of this general-purpose machine, but organizational work is still going on and the date of completion of the development of this motor block is postponed. A gas pump for watering gardens and a unit for the individual milking of cows (AID-1), whose output was mastered by the Rezekne Milking Installation Plant, is in great demand by the rural population. However, the needs of the rural population for these articles are not met. For example, for 1979 a total of 6,500 gas pumps were allocated for consumer cooperatives, or two-fifths of the number annually sold by cooperative organizations during past years.

The time has come to change the situation with the production of orchard and garden implements and small-scale mechanization equipment. It seems that the development and production of individual types of small-size equipment should be planned with a centralized allocation of material and labor resources for this and control

over their implementation should be established. At present planning bodies do not establish the volumes of production of orchard and garden implements for most industrial branches, these volumes being determined by enterprises at their discretion. As yet local reserves and kolkhoz industries are poorly utilized for an increase in the production of this type of product. The solution of these problems will make it possible to increase the production of orchard and garden implements and to meet the demand of the rural population for them.

Improvement in the procedure of purchases of the surplus output of private subsidiary farms is one of the tasks of consumer cooperatives, whose accomplishment should contribute to the development of these farms. In his speech at the 16th USSR Trade-Union Congress L. I. Brezhnev pointed to the advisability of placing on consumer cooperatives great responsibility for an organization of the sale of surplus agricultural products of the rural population and kolkhozes. Now the system of consumer cooperatives is the largest procurement organization making state purchases of more than 60 types of agricultural products and raw materials. In the last 4 years their average annual procurement turnover totaled 7.6 billion rubles, including of state purchases, 5.8 billion rubles. In 1978 consumer cooperatives procured 7.6 million tons of potatoes, or more than 50 percent of the total volume of their state purchases in the country and, respectively, 6.2 million tons of vegetables--34 percent--0.9 million tons of fruits--21 percent--and 1.3 million tons of melon crops--67 percent.

In our country, apart from the system of consumer cooperatives, there is no other economic system that would be better prepared to draw commodity resources produced on the population's private farms into turnover. In 1978 the share of private subsidiary farms in state purchases was as follows: potatoes, 25 percent; vegetables, 7 percent; meat, 5 percent; wool, 16 percent. Consumer cooperatives purchased a considerable part of the products from the population. For example, at agreed prices they purchased from the population 597,000 tons of meat (in carcass weight), 10.6 million head of poultry, 87,000 tons of vegetable oil and large quantities of other agricultural products worth 2.7 billion rubles.

As calculations show, the annual commodity resources of surplus meat among the population throughout the country total 1.3 to 1.5 million tons and of vegetables and fruits, 6 and 4 million tons respectively. In fact, however, the surplus meat purchased by consumer cooperatives does not exceed 34 percent of its commodity resources among the population, surplus potatoes, 46 percent, surplus vegetables, 51 percent and surplus melon crops, 65 percent. If the forthcoming increase in the production of agricultural products on the population's private subsidiary farms is taken into account, the possibilities of expanding purchases will increase.

At the same time, consumer cooperatives do not yet fully utilize the possibilities of drawing surplus agricultural output into turnover. This is indicated by the fact that, for example, in Altayskiy Kray the population has almost twice as much livestock in private use as in Stavropol'skiy Kray, but meat purchases there are lower by a factor of 1.5. In Stavropol'skiy Kray more than 40 percent of the resources available to the population are utilized, whereas in Altayskiy Kray, only 16 percent.

In order to increase the purchases of surplus products from the population, the Central Union of Consumer Societies and its bodies are improving the work of the procurement apparatus, strengthening the material and technical base of procurements, refining purchase prices, improving information on market requirements and expanding the purchases of products on the basis of long-term contracts. More than 5 million contracts with the population for the sale of surplus products were concluded in 1979. The experience of some unions of consumer societies in the establishment of farms, where small hogs, rabbits and chicks are bred for sale to local residents, deserves to be disseminated. Furthermore, for the fattening of animals concentrated feed and metal netting for cages are sold to them on a contractual basis.

The potentials for the production of products of private subsidiary farms are also connected with an improvement in the sale of their output. It is important not only to purchase surplus products from the population everywhere, but also to deliver them to the consumer.

The population sells a considerable part of the products on the kolkhoz market. In 1979 the volume of commodity turnover of the kolkhoz market reached 6.9 billion rubles and the volume of sale of surplus agricultural products purchased from the population by consumer cooperatives totaled 1.7 billion rubles. The fact that the rates of growth of the commodity turnover of consumer cooperatives in the sale of surplus agricultural products (on the unorganized market) are much lower than the rates of growth of their sale on the kolkhoz (unorganized) market puts us on guard.

City cooperative trade in agricultural products has an effect on the development of the kolkhoz market. Therefore, the workers of consumer cooperatives are, first of all, required to expand the network of enterprises of city cooperative trade. The sale of products of private subsidiary farms through the network of such trade organizations frees rural workers from the need to spend time and money on the delivery of products to the market and their sale. Kolkhoz members and sovkhoz workers and employees can use more time in public production and on raising their educational and cultural level.

Thus, economic relations between private subsidiary farms and cooperative organizations are varied and close. They encompass the sphere of production, procurement and sale of the output of the population's private subsidiary farms. The further development and improvement of the forms of relations between public and private subsidiary farms will contribute to an increase in the rate of production of products on them for the purpose of meeting the population's ever increasing needs for valuable food products.

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PULSE CROP PRODUCTION PROBLEMS REVIEWED

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[Article by Ye.M. Sinitayn, leading agronomist of the Main Administration for Grain Crops and General Problems of Agriculture of the USSR Ministry of Agriculture: "Pulse Crop Production Problems"]

[Text] The production of pulse crop grain, as is well known, is of tremendous importance not only for satisfying the population's requirements for food products but also for strengthening the feed base in livestock husbandry.

It is also difficult to exaggerate the agrotechnical and organizational-economic importance of pulse crops. They are considered to be one of the best predecessor crops for promoting an expansion in the grain fields, for increasing the production of grain and for improving its quality.

Recently the farms in the Mariyskaya ASSR, Krasnodarskiy and Krasnoyarskiy Krays and in Kuybyshevskaya, Kurganskaya, Orenburgskaya and Irkutskaya Oblasts increased their production of pulse crop grain. However, for the Russian Federation on the whole, the gross yield for these crops decreased by 13 percent. A considerable reduction also took place in their production in the nonchernozem zone of Russia.

On the whole for the Ukrainian SSR, positive solutions are being found for the problems concerned with increasing the pulse crop yields. At the same time, insufficient attention is being given to these problems in Khar'kovskaya, Voroshilovgradskaya, Zhitomirskaya, Volynskaya, Sumskaya, Zakarpatskaya and Ivano-Frankovskaya Oblasts.

The production of pulse crops has been reduced sharply in the Moldavian SSR. The production of lentils has actually been curtailed in Saratovskaya Oblast, long praised for its production of this crop. Its production has been discontinued in the Tatarskaya ASSR and Tambovskaya Oblast. The situation has deteriorated with regard to the production of feed lupine seed in Bryanskaya, Smolenskaya, Kaluzhskaya and Orlovskaya Oblasts of the RSFSR, in the Belorussian SSR and in Chernigovskaya, Zhitomirskaya, Volynskaya, Kiyevskaya and other Oblasts of the Ukrainian SSR. Only slowly are solutions being found for the problems concerned with increasing the gross yields of beans, especially in the RSFSR and the Moldavian SSR.

For the country on the whole, during the Tenth Five-Year Plan, pulse crops were grown for grain purposes on 5.08 million hectares of land, their average annual

yield of grain was 6.86 million tons and their cropping power -- 13.5 quintals per hectare.

During the years of the Tenth Five-Year Plan, the production of peas and beans increased somewhat while the production of vetch, feed lupine and lentils decreased considerably. Compared to the Ninth Five-Year Plan, the average annual yield of pulse crop grain in the RSFSR decreased by 590,000 tons, Belorussian SSR -- by 63,000, Lithuanian SSR -- by 26,000 and in the Moldavian SSR -- by 45,000 tons. This took place as a result of a reduction in the area under crops. At the same time, the production of pulse crops in the Ukrainian, Uzbek and Kazakh Union Republics increased by 275,000, 2,000 and 8,000 tons respectively.

The plans for 1981 and subsequent years call for the pulse crop plantings to be expanded and distributed as follows: in the nonchernozem zone of the RSFSR -- peas, vetch and feed lupine; in the central chernozem region -- peas, vetch, lentils, peavine and beans; in the north Caucasus -- peavine, chick peas and peas; in western and eastern Siberia and in the Urals -- peas and vetch; in the Ukraine -- peas, vetch, peavine, feed lupine, lentils and beans; in Moldavia -- peas and beans; in Belorussia and the Baltic region -- feed lupine, peas, vetch and feed beans; in northern Kazakhstan -- peas and chick peas.

Moreover, it is assumed that two varieties of one pulse crop will as a rule be grown at each specific farm, with the varieties differing in terms of their growing seasons. The plans call for 97 percent of the feed lupine crop to be produced in Belorussia, Lithuania, the central region of the RSFSR and in the forest district of the Ukraine. The production of marketable beans should be organized at kolkhozes and sovkhoses in Voronezhskaya, Belgorodskaya, Vinnitskaya, Cherkasskaya, Ternopol'skaya, L'vovskaya, Odesskaya and Nikolayevskaya Oblasts and in the Moldavian and Georgian SSR's and lentils -- in Saratovskaya, Khar'kovskaya, Poltavskaya and Tambovskaya Oblasts and in the Tatarskaya ASSR.

The seed laid away for this year's crops at a majority of the kolkhozes and sovkhoses is less than the amount required and only a small amount of seed is available in the state resources. Taking into account the impending and considerable expansion in the plantings of pulse crops for grain, consideration must necessarily be given to each quintal of seed and special attention must be given to improving the sowing qualities and using the seed in a thrifty manner. Towards this end, it will be necessary to calibrate all of the seed and ensure the separate sowing of each fraction. In addition and in advance, no later than 2 weeks prior to sowing, the seed should be disinfected using phenthiuram-molybdate (400-600 grams per quintal) or TMD [tetramethylthiuram disulfide] phenthiuram, tigam or benomil (300-400 grams per quintal). In order to raise the germinative capacity and germinative energy, warm-air heating of the seed should ideally be carried out prior to sowing out under the sun, in grain dryers or in ventilated hoppers.

In connection with the shortage of seed and by way of an exception, the sowing norms for peas and vetch for grain should be reduced during 1981 and the seed thus saved should be used for expanding the areas sown in these crops.

This is based upon the fact that in recent years the raised sowing norm increased the cropping power of the pulse crops by only 5-10 percent, while at the same time

the expenditure of seed increased by 20-25 percent. It is possible that a decrease in the sowing norm for peas and vetch will lower their cropping power to a minor degree, but the additional grain obtained from having expanded the plantings will ensure an increase in the production of these crops. Feed lupine and feed beans for grain, in the interest of economizing in the use of seed, should be sown using only the wide-row method. It must be borne in mind that favorable conditions for the development of weeds are created in sparse plantings. In this regard, the organization of a campaign against weeds must be intensified considerably using all available agrotechnical methods and chemical agents.

Peas, vetch, lupine and feed beans furnish maximum seed yields following early sowing periods. According to data supplied by state strain testing stations and the experience of leading farms, a delay of just 7 days in sowing, compared to the optimum period, lowers the cropping power for the grain in the nonchernozem zone of the RSFSR and in Belorussia by 2-3 quintals per hectare and in the central chernozem region and the forest-steppe region of the Ukraine -- by 3-5 quintals per hectare. Thus the sowing of these crops during the initial days at the commencement of sowing operations serves to guarantee that a high yield will be obtained during 1981.

During the spring sowing work, efficient control should be established over the quality of the sowing and especially over the depth of seed placement.

On heavy textured clay soils the seed is placed at a shallow depth and on light sandy loam and sandy soils -- at a greater depth: for peas this would be 5-8 centimeters respectively, lupine -- 2-4, vetch -- 5.6, feed beans -- 6-8 and beans -- 4-5 centimeters. During dry weather the seed is placed at a greater depth so as to ensure that it comes to rest in a damp layer of soil.

Inoculation of the seed must become an important element of the technology for cultivating pulse crops. A bacterial preparation -- peat nitragin -- which was developed at the All-Union Scientific Research Institute of Agricultural Microbiology, has proven its worth. It differs from soil nitragin in that it is more technological in nature. The inoculation of seed in the new regions in which the crops are being grown and also in regions where there is a poor survival rate for local races of nodule bacteria produces high increases in yield. Thus, on an irrigated tract at the 30 Let Kazakhskoy SSR Kolkhoz in Pavlodarskaya Oblast, the treatment of seed with nitragin in 1979 produced an increase in yield for feed beans of 7.4 quintals per hectare and for feed lupine -- 9.2 quintals per hectare.

Even in regions where one or another pulse crop has been under cultivation since olden times and a large number of specific races of nodule bacteria has accumulated in the soil, inoculations in some instances exert a positive effect on the yields, raise the resistance of the plants against fungus diseases of soil origin and they increase the protein content in the grain. In 1979, on an experimental plot of the All-Union Scientific Research Institute of Pulse and Groat Crops, an increase of 2 quintals per hectare was obtained in the yield of peas. The inoculation of seed insures the process of nodule development against the destructive effect of random factors. The low cost of the preparation makes it possible to employ it on an extensive scale. Unfortunately, Glavmikrobioprom is only slowly developing its capability and mastering the production of peat nitragin. Agriculture is being

supplied with a negligible amount of nitragin for peas and none whatsoever for beans, lentils, chick peas, feed lupine and others.

In the interest of increasing the production of pulse crop grain in every possible way, special importance is attached to planting them following the best predecessor crops -- corn, sugar beets, potatoes and winter crops.

Many kolkhozes and sovkhoses and also rayons and oblasts, as a result of the correct selection of predecessor crops, have increased sharply the productivity of a hectare of peas, vetch, lentils and others. At the kolkhozes imeni Krupskaya in Arkadaskiy Rayon and Krasnyy Oktyabr' in Balashovskiy Rayon of Saratovskaya Oblast, the productivity of lentils sown following good predecessor crops reached 18 quintals per hectare. At the Mayak Kolkhoz in Khristinovskiy Rayon in Cherkasskaya Oblast, peas are planted on approximately 10 percent of the arable land and following grain corn and winter wheat; a yield of up to 50 quintals of grain per hectare is being obtained.

In addition to utilizing the residual effect of fertilizers in a productive manner, pulse crops also respond to direct applications of fertilizer. The fertilizer dosages are dependent upon the nutrient supplies in the soil and their ratios. For example, on light textured soils the biological requirements of peas are more completely satisfied by a nitrogen, phosphorus and potassium ratio of 1:1.5:2 and on loamy soils -- 1:1:1.5.

According to data supplied by the All-Union Scientific Research Institute of Pulse and Grain Crops, the withdrawal of mineral elements from dark grey forest soils, per quintal of principal output and in the case of peas is (in kilograms) -- nitrogen 6.5, phosphorus 1.5 and potassium 2.6; beans -- 4.8, 1.6 and 4.3 respectively; fodder beans for grain -- 7.8, 1.6 and 2.5.

It should be borne in mind that on the average the plants withdraw the elements from the mineral fertilizers, during the first year of application, as follows (in percent): nitrogen -- 60, phosphorus -- 20 and potassium -- 70. Depending upon the conditions for nitrogen fixation, up to 75 percent of the nitrogen requirements of the pulse crops may be satisfied by nitrogen from the air.

Phosphorus-potassium fertilizer reserves should be sought in all areas for the entire area sown in pulse crops, in the interest of satisfying the full requirement for the planned yield. Nitrogen fertilizers should ideally be applied in a dosage of 1/3 - 1/2 of the requirement for all tracts containing less than 10 milligrams of easily hydrolyzed nitrogen per 100 grams of soil.

It is best to apply the phosphorus fertilizer to the drill rows during sowing. This raises its effectiveness. When sowing peas at kolkhozes and sovkhoses in Gayvoronskiy Rayon in Kirovogradskaya Oblast, 50 kilograms of granulated superphosphate are applied to the drill rows per hectare, thus producing 3-4 additional quintals of grain.

White lupine, when sown early, requires a great amount of nitrogen. It responds well to drill row applications of 15-30 kilograms of nitrogen, or 3 quintals of ammonium nitrate per hectare during pre-sowing cultivation.

A raised acidity level in the soil solution suppresses the vital activity of the nodule bacteria and their fixation of atmospheric nitrogen almost ceases. In the process, the productivity of pulse crops, with the exception of lupine and seradella, decreases sharply. Under these conditions, the application of lime at the rate of one half or a complete norm, according to hydrolytic acidity, raises the cropping power of peas, beans and vetch by 10-50 percent. The protein and calcium content in the plants increases and this exerts a positive effect on their feed value. It should be borne in mind that the calcium of applied lime materials improves, while the potassium impedes the assimilation of phosphorus. It is for this reason that the potassium dosages are increased when carrying out liming work. Applications of molybdenum serve to raise the pulse crop yields. On sod-podzolic and podzolic soils in the nonchernozem zone of the RSFSR, Belorussia and the Ukraine, the treatment of seed with molybdenum furnishes an increase in grain of 2-3 quintals per hectare, on grey forest soils -- 3-4 quintals per hectare. Molybdenum intensifies nitrogen fixation and it raises the resistance of plants against various diseases.

The use of molybdenum is being combined with the disinfection of seed and in the process it is being expended at the rate of 25-50 grams per quintal of seed. Extensive use should also be made of a new preparation -- phenthuriam-molybdate -- it ensures simultaneous disinfection and molybdenization of the seed. The treatment of seed with zinc sulphate is effective in the southern regions of the Ukraine and in Moldavia. In the forest and forest-steppe zones, pulse crops respond well to the use of boric fertilizers, especially on tracts that have been limed.

The planting of pulse crops in the vicinity of perennial leguminous grasses in which sitona weevils are wintering is not recommended. This pest causes damage to seedlings and its larvae destroy the nodules on the roots of plants. In addition to adversely affecting the yields, this also lowers the value of the pulse crops as predecessor crops.

The quality of the pre-sowing treatment of soil is of special importance. The more thoroughly it is cultivated and the smoother the surface, the greater will be the amount of moisture retained in the soil, the seed will be placed at a more uniform depth and more healthy seedlings will appear. The harvesting units operate more productively on such fields and the grain losses are less.

In the spring the moisture is worked into the soil using heavy harrows: on coherent soils -- in two tracks and on light textured soils -- in one (crosswise to the plowing). This work should be completed in one or two days. Pre-sowing cultivation with simultaneous harrowing or smoothing out of the soil is carried out for peas, peavine, beans and vetch to a depth of 6-8 centimeters on light textured soils and to 10-12 centimeters for heavy soils and for lupine -- to no more than 5-6 centimeters. Importance is attached to ensuring that no pause develops between the pre-sowing cultivation and the sowing work.

In this regard, extensive use should ideally be made of multi-purpose units (KA-3.6), which are capable of carrying out several operations during just one pass: application of fertilizer, loosening of soil, packing of soil and sowing. Their use makes it possible to reduce the amount of time required to carry out the pre-sowing soil cultivation and sowing work and to reduce labor expenditures

compared to the conventional technology. In regions subject to wind erosion, use is made of needle-shaped harrows or cultivator-sweeps for the pre-sowing loosening of soil. Under these conditions, the SZS-2.1 stubble field sowing machines produce fine results in the sowing of pulse crops. Following sowing, the field must necessarily be packed -- an especially important factor in the dry steppe and forest-steppe regions. This method serves to bring moisture up to the seed from the lower and more damp soil layers and it reduces the uneven nature of the soil's surface. The packing is best carried out using ring-lug (EKKSh-6) or ring-toothed rollers (KKN-2.8, 2KKN-2.8, ZKKN-2.8). The sowings should not be packed following precipitation or on heavy soils.

High yields can be expected only in those areas where weed control measures are carried out in a timely and complete manner. Many farms are failing to attach proper importance to one simple and yet effective means for combating weeds -- that of harrowing the plantings and thus destroying up to 60-80 percent of the weed seedlings. As a rule, the leading farms harrow the soil both prior to and following the appearance of the seedlings. This method must become a mandatory part of the cultivation technology.

The initial harrowing should be carried out 4-5 days following the sowing work and it should be completed within 1-2 days. During a cold and prolonged spring period, when the weed seedlings appear later, an additional pre-seedling harrowing is possible. Harrowing of the seedlings is conducted during the second half of the day, at which time the plant turgidity is low and they are less fragile. The unit must move crosswise or at an angle to the direction of sowing and at a speed of no more than 6 kilometers per hour. The unit must advance in a smooth and uniform manner, with each tooth leaving its own track. The covering over of the plants with soil must not be tolerated. A delay of 4-5 days in carrying out the harrowing can lead to a sharp reduction in its effectiveness.

An important role is played by chemical agents designed to protect crops against weeds. Of a large group of herbicides available for pulse crops, the following are recommended: prometrin, linuron, sodium trichloracetate (TKhA) and 2M-4KhM.

Prometrin and linuron are employed for practically all pulse crops, prior to the appearance of the seedlings and in a dosage of 1.5-2 kilograms of active agent per hectare. These herbicides affect dicotyledonous and herbaceous weeds. They decompose in the soil over a period of 3-4 months and thus they exert no residual effect on other crops.

Sodium trichloracetate (TKhA) produces fine results on fields contaminated by herbaceous weeds. For peas and depending upon the type of soil and its mechanical structure, it is applied during pre-sowing cultivation and in a dosage of 4-12 kilograms of active agent per hectare. The effectiveness of this herbicide increases considerably on soils having a high humus and nutrient content.

In order to destroy dicotyledonous and perennial root-sucking weeds (sowthistle, bindweed and horsetail), the peas are sprayed with 2M-4KhM herbicide in a dosage of 2-3 kilograms of active agent per hectare. Its use during the early phases of weed development produces high results. Herbaceous weeds and a majority of the cruciferous weeds, as well as daisies and field mint, possess a resistance to this herbicide.

The effectiveness of the mentioned herbicides is greatly dependent upon the correct dosage being selected, the method of application, the crops on which they are to be used, the soil-climatic conditions and the nature and degree of crop contamination. For example, for light textured soils having a low humus content the dosages of soil herbicides (prometrin, linuron) should be minimal and on clay and rich with humus soils -- maximum dosages.

The periods for applying these herbicides are dependent upon the biology of the crop and the moisture content of the soils. In the arid zones they should be applied during pre-sowing cultivation and under damp conditions -- on the soil's surface following sowing. It has been established that peas possess the greatest resistance to 2M-4KhM during the phase of 3-5 leaves, at which time the plants have their heaviest layer of wax coating. A delay in carrying out this measure tends to suppress the growth processes and lower the nitrogen fixation capability of the peas. During dry weather and for the purpose of avoiding blight, 2M-4KhM should be applied after the heat has abated.

The majority of the herbicides used on pulse crop plantings possess a selective effect, that is, they suppress one or several groups of weed plants while failing to exert any destructive effect on others. For example, linuron destroys annual dicotyledonous and herbaceous weeds, prometrin -- dicotyledonous weeds and the herbicide 2M-4KhM -- perennial weeds. The joint use of prometrin (prior to seedlings) and 2M-4KhM (after seedlings have appeared) makes it possible to remove weeds more completely from plantings.

The combining of chemical and agrotechnical measures for combating weeds is effective. On the grey forest soils in the nonchernozem zone, an application of prometrin in a dosage of 2 kilograms of active agent per hectare following sowing and harrowing of the pea seedlings made it possible to clear the plantings of annual weeds.

In the system employed for tending pulse crops, great importance is attached to improving the complex of measures for protecting plants against pests and diseases. A considerable amount of damage is inflicted upon plants by aphids, moths and sitona weevils and in the southern regions of the country -- by brukhus. Chemical, agrotechnical and biological means for protecting plants are employed against them.

Agricultural production is being supplied with an entire series of insecticides. In the event of the mass spread of sitona weevils (more than 40 specimens per square meter), use is made of polychlorpinene (2 kilograms per hectare) or metaphos (1 kilogram per hectare); against the pea moth -- metaphos (0.5-1 kilogram per hectare) or chlorophos (1-1.5 kilograms per hectare); against brukhus -- seed fumigation and during the period of mass flight of the beetle -- treatment of the plantings with chlorophos (1 kilogram per hectare) or metaphos (1 kilogram per hectare). Metaphos and Malathion insecticide in a dosage of 0.5 kilograms per hectare are used for combating aphids. The sayphos preparation is producing fine results. It is used both for treating seed and for spraying plantings (1 kilogram per hectare). Rogor in a dosage of 1-1.2 kilograms per hectare is characterized by a high degree of harm to aphids and weak toxicity for warm-blooded animals.

More extensive use should be made of biological methods for combating pulse crop pests. The artificial propagation of trichogrammas and their release in quantities

of 30,000-50,000 specimens per hectare, at the commencement of the blossoming period for peas, should be employed against the pea moth. If there is a mass spread of the moths, the release of trichogrammas should be repeated.

In order to increase the production of pulse crops, more extensive use should be made of the experience of leading farms, the plantings should ideally be assigned to specialized teams and the teams should be supplied with adequate quantities of the needed equipment, mineral fertilizers, herbicides and pesticides. The work performed by these teams should be organized on the basis of prepared technological charts, with the job contract plus bonus wage system being introduced into operations.

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EFFECTIVENESS OF FERTILIZING WINTER WHEAT ACCORDING TO CLIMATE DISCUSSED

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[Text] All factors that affect the yield of winter wheat can be divided into two groups--those that can be regulated and depend on the quality of farming (variety, agrotechnology, fertilizer, and others) and those that cannot be regulated and that are related to meteorological conditions. We have set ourselves the goal of finding the geographic laws of the effect of fertilizers on the yield of winter wheat in our country and to compare our data with similar data received from areas with similar climatic conditions in other countries.

To do this we have used the results of 728 short-term experiments in the geonetwork in 1970-1978 (626 in dry-farming conditions and 102 using irrigation) and of 86 studies conducted in other countries.

The average yield of winter wheat and the effectiveness of mineral fertilizers were determined according to zones and provinces that were drawn according to natural and agricultural regionalization. Each zone and province is characterized by certain agroclimactic indicators whose total affects the potential resources of a particular territory. In order to have a single approach to the evaluation of climate we used a standard scale to classify agroclimatic indicators. Table 1 presents the indicators that are most important for agricultural production (4,9). The moisture coefficient, KY, is used as the indicator of moisture supplies.

$$KY = \frac{P}{\Sigma d},$$

where P - precipitation per year, millimeters; Σd - total deficit of moisture in the air (millimeters). The type of moisture dynamics was determined by means of monthly values for the indicators of atmospheric moisture.

Table 1. Agroclimatic Features of the Zones and Provinces of the USSR

(1) Республика, автономный район	(2) Примечания к карте	(3) Температурные условия (4) Влажность воздуха				Средняя температура воздуха		(11) Средняя температура воздуха
		Σ t ≥ 10 °C	средняя температура в год	Σ t ≥ 10 °C	средняя температура в год	Средняя температура воздуха	Средняя температура воздуха	
(12) Центральный район РСФСР	(23) 1-3	1800-2200	10-14	50-60	50-60	50-60	50-60	50-60
(13) Центрально-черноземный район	(24) 1-3	2700-2800	13-15	400-600	400-600	400-600	400-600	400-600
(14) Поволжский район	(25) 1-3	2600-3200	16-18	350-500	350-500	350-500	350-500	350-500
(15) Северо-Кавказский район	(26) 1-3	2800-3500	17-19	400-600	400-600	400-600	400-600	400-600
(16) Понтийский район	(27) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(17) Алтеетский район	(28) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(18) Сибирский район	(29) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(19) Сибирский район	(30) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(20) Сибирский район	(31) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(21) Сибирский район	(32) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700
(22) Сибирский район	(33) 1-3	2200-2800	14-16	600-700	600-700	600-700	600-700	600-700

Key to Table 1:

1. Republic, economic region
2. Provinces and index
3. Supply of warmth
4. Supply of moisture
5. Number of days
6. Annual precipitation
7. Dynamics of moisture supply
8. Height of snow cover (cm)
9. Of the coldest month
10. Of the warmest month
11. Average atmospheric temperature
12. Central region of the Non-Chernozem Zone
13. Central Chernozem region
14. Volga region
15. Northern Caucasus region
16. Poles'ye
17. Forest-steppe
18. Steppe
19. Dry steppe
20. Lithuanian SSR
21. Kazakh SSR
22. Ukrainian SSR
23. RSFSR
24. Central Russian
25. Southern Russian
26. Caucasus region
27. Belorussian
28. Ukrainian
29. Ukrainian
30. Southern Ukrainian
31. Baltic States
32. Aralo-Balkhashskaya
33. Aralo-Balkhashskaya

Table 2. Average Yield of Winter Wheat and Return on 1 Kilogram of Active Fertilizer Based on the Increase in Grain (kilograms) in Republics and Economic Regions

Республика, союзный район (1)	ВКП (вексель) при активном возделывании (2)	Урожайность (3)	Тип почвы (4)	Средн. (5)	Урожай (6)		Удобрения в среднем (7)		Возврат на 1 кг (11)
					в год	в год	на 1 кг	на 1 кг	
(13) Центральный район (включая Калининскую область)	188	73	Дерново-подзолистая (24)	Мордовская 808 (35)	23.4	23.1	9.7	9.0	8.8
(14) Центрально-Черноземный район	129	18	Водоразливная и тяжелая черноземы (25)	Мордовская 808 (34)	21.5	20.9	9.4	8.9	8.3
(15) Поволжский район	90	18	Средне-каштановые (26)	Мордовская 808 (35)	20.8	23.5	9.7	4.1	8.8
(16) Северо-Кавказский район	148	143	Карбонатно-каштановые и каштановые (27)	Восточная 1. (36) Саратовская 192 (37) Рязанская 192 (38) Кавказ (39) Крымскостепная 19 (40)	28.9	47.6	8.7	8.2	7.7
(17) Паша	121	148	Дерново-подзолистая (28)	Мордовская 808 (34)	20.4	20.4	11.0	6.6	6.9
(18) Лесостепь	137	148	Дерново-подзолистая (29)	Мордовская 808 (34)	21.9	40.8	8.9	6.2	6.4
Средн. (19)	124	148	Дерново-подзолистая (30)	Алгоза (43)	32.8	42.4	9.6	8.2	8.8
Средн. степь (20)	110	148	Дерново-подзолистая и каштановые (31)	Восточная 1 (36) Кавказ (39)	30.3	37.6	7.3	6.3	6.5
Лесостепь (21)	108	148	Дерново-подзолистая (32)	Мордовская 808 (34)	32.1	48.2	12.1	7.2	7.0
Каштановая (22)	12	148	Каштановая (33)	Восточная 1 (39)	19.3	26.8	8.2	4.0	3.7

* Нормализованные материалы Госплана РСФСР. (23)

Key to Table 2:

1. Republic, economic region
2. BKP (points) with natural moisture supplies
3. Number of tests
4. Type of soil
5. Variety
6. Yield, quintals per hectare
7. Fertilizer, average per year
8. Without fertilizer
9. With NPK fertilizer
10. Increase, quintals per hectare
11. Total
12. Return
13. Central region of Non-Chernozem Zone
14. Central Chernozem region
15. Volga region
16. Severo-Kavkazskiy Rayon
17. Poles'ye
18. Forest-Steppe
19. Steppe
20. Dry steppe
21. Lithuanian SSR
22. Kazakh SSR
23. Materials of the Geonetwork of VIUA used
24. Sod-podzol
25. Leached and typical chernozems
26. Regular light-chestnut chernozems
27. Carbonate-micellar and carbonate chernozem
28. Sod-podzol
29. Sod-podzol, gray forest, regular chernozem
30. Typical and regular chernozem
31. Regular and southern chernozem
32. Sod-gley
33. Dark serozem, regular chernozem
34. Mironovskaya-808
35. Mironovskaya yubileynaya
36. Bezostaya-1
37. Severodonskaya-292
38. Rostovchanka
39. Kavkaz
40. Krasnodarskaya-29
41. Polesskaya
42. Il'ichevka
43. Aurora
44. Yubileynaya-50
45. Odesskaya
46. Ukrainian SSR

In order to determine the relationship between the harvest of winter wheat and the effectiveness of fertilizers and climatic conditions it is not enough to utilize discrete indicators (precipitation, temperature of the air, supply of warmth, etc.), because with an increase in warmth the supplies of moisture decrease, the dynamics of moisture supply are altered and the average monthly temperatures change. Moreover, the soil type changes according to zone, which affects the factor under study--the harvest yield. The complex BKP (bioclimatic factor) presented by D. I. Shashko reflects the total climatic and biological indicators (9).

$$BKP = K_p \frac{CT_{\geq +10^{\circ}C}}{1000^{\circ}C},$$

where BKP -- [BKP], the relative size of biological potential; $CT_{\geq +10^{\circ}C}$ -- sum of temperatures over $+10^{\circ}C$; $1000^{\circ}C$ -- sum of temperatures within the current parameters of field cultivation; K_p -- the coefficient of biological productivity which depends on the moisture supply for vegetation and which is the ratio of the productivity when there is a shortage of moisture to maximum productivity when there is sufficient moisture.

The bioclimatic potential is expressed in points (9). As an example, let us calculate the BKP for the Central Chernozem Zone. Since $\Sigma t_{\geq +10^{\circ}C}$ for this rayon is an average of $2500^{\circ}C$ and the K_p for a semi-moist forest-steppe is 0.92 (4), then:

$$BKP = 0.92 \frac{2500^{\circ}}{1000^{\circ}} = 2.3$$

In order to express BKP in points it is necessary to multiply the relative quantity by a constant, 55 (9).

$$BKP \text{ (points)} = 2.3 \times 55 = 126$$

A low biological productivity corresponds to 40-60 points; somewhat higher--60-85; average--85-120; slightly high--120-155; high--155-190; and very high--over 190 points.

Table 2 presents the significance of biological potential, which reflects the biological productivity in various zones, the average yield of winter wheat and the return on fertilizer in terms of an increase in yield.

When considering the yield of winter wheat while fertilizer is applied we took the optimal variant in each test and calculated the average for all tests in each province. All of the studies were grouped within zones and provinces according to low, average or high biological productivity. The grouping of the tests in this manner has revealed that under conditions of low biological productivity the yield of winter wheat was 18.3-26.5 quintals per hectare (without fertilizer and with NPK fertilizer); average--26.1-34.6 quintals per hectare; and high--33.8-43.2 quintals per hectare.

In our country (with natural irrigation) 5 percent of the territory belongs in the belt of high biological productivity and winter wheat is not cultivated here (9). In dry zones, where this crop is cultivated on considerable areas, biological productivity is on the increase when irrigation is available (Table 3).

Table 3. Yield of Winter Wheat Cultivated Under Irrigation and Dry-Farming Conditions

Республика, экономический район		(2) ВКП (баллы) при увлажнении		Условия возделывания	Число опытов*
		естественном	оптимальном		
(1)		(3)	(4)	(5)	(6)
(7) Северо-Кавказский район	} (12)	149	176	Без орошения	{13} 143
(8) Поволжский район		90	160	с орошением	
(9) Сухопосевная зона		110	184	Без орошения	18
{10} Украинской ССР				с орошением	27
{11} Кавказская ССР				Без орошения	43
		12	182	с орошением	31
				Без орошения	14
				с орошением	23

(15) Продолжение

		(16) Урожай (ц/га)		Прибавка (ц/га) (19)	Средняя доза NPK (кг/га) (20)	Окупаемость 1 кг д. в. NPK прибав- кой (кг) (21)
Республика, экономический район (1)		без удобрений (17)	по NPK (18)			
(7) Северо-Кавказский район	} РСФСР (12)	58.6	47.6	8.7	62-77-33	8.1
(8) Поволжский район		49.2	59.4	12.2	130-85-17	8.3
		26.6	53.5	6.7	61-55-18	8.8
(9) Сухопосевная зона		51.0	52.4	21.4	129-94-34	8.3
(10) Украинской ССР		50.7	57.6	7.3	63-62-25	4.9
(11) Казахская ССР		49.7	58.7	18.0	127-87-23	8.3
		18.3	28.5	8.2	40-37-5	10.0
		42.7	59.6	17.4	103-80-28	8.3

*Materials of the Geonetwork of VIUA and data in sources 1, 3, 6, and 7 were used.

Key to Table 3:

1. Republic, economic region
2. ВКП (points) with moisture supply
3. Natural
4. Optimal
5. Cultivation conditions
6. Number of tests
7. Northern Caucasus region
8. Volga region
9. Dry-Steppe zone
10. Ukrainian SSR
11. Kazakh SSR
12. RSFSR
13. Without irrigation
14. With irrigation
15. Continuation
16. Yield (quintals per hectare)
17. Without fertilizer
18. With NPK
19. Increase (quintals per hectare)
20. Average dose of NPK (kilograms per hectare)
21. Return on 1 kilogram of active substance of NPK in terms of increase (kg)

The size of the harvest of winter wheat cultivated on dry-farming land or irrigated land correlates well with the indicators for bioclimatic potential, as we can see from Tables 4 and 5.

With the growth of BKP under natural irrigation conditions there is a regular increase in the yield of winter wheat on unfertilized and fertilized soils. With optimal moisture the BKP indicator changes. Whereas with regard to natural moisture the Kazakh SSR belongs to the zone with a very low biological productivity (12 points), with optimal irrigation it moves up into the category of very high productivity (192 points). The northern Caucasus and the dry-steppe zone of the Ukrainian SSR also move into the category of very high productivity with irrigation. This is reflected in the size of the harvests.

Thus, in zones with large heat supplies but with a low moisture coefficient and an unfavorable dynamics of moisture-supply, with irrigation it is possible to create the conditions for a high and very high biological productivity, thereby producing yields of winter wheat of up to 60 quintals per hectare.

An analysis of test data has shown that within each soil-climatic zone the yields fluctuated sharply (Table 6), which is related primarily to the changes in weather conditions. This is especially true as we move south (the coefficient of variation is 38-46 percent). When fertilizer is used the coefficient of variation usually drops by 5-7 percent, and with irrigation--by 2-16 percent. The use of irrigation and the application of fertilizer significantly equalize the yields of winter wheat according to years and decrease the coefficient of variation to 14, 15 and 19 percent, which enables us to produce large and stable harvests.

The extensive cultivation of winter wheat in our country and abroad has resulted in a great number of varieties. Over 20 ecological groups have been singled out according to geography. A particular morphophysiological type or subtype of winter wheat corresponds to each ecological group. Classification according to the morphophysiological principle (F. M. Kuperman) considers the duration of the stages of organogenesis and such features as rate of maturity, drought resistance, resistance to cold and potential productivity (8). According to F. M. Kuperman, there are three types (8, 9 and 10) and eight morphophysiological subtypes of winter wheat categorized in regions in our country as well as abroad. Based on this classification we can make a comparative study of the productivity of wheat and the effectiveness of fertilizer in our country and abroad within a single morphophysiological subtypes.

In connection with this a study was included on the effectiveness of fertilizer in Lithuania (despite the insignificant area of winter wheat there), where cultivation conditions are analagous to those in the GDR, Belgium, the Netherlands, Denmark and Great Britain. The Northern Caucasus (USSR) is similar to Yugoslavia, Bulgaria, Italy and some regions of the USA in cultivation conditions.

Because of the fact that the results of studies abroad are not completely reflected in literature, we have included data only on the GDR (5), Bulgaria (10-12) and Yugoslavia (13,14), for which we were able to find a sufficient quantity of essential information (Table 7). The data in Table 7 attests to the approximately equal level of yields in the Lithuanian SSR and the GDR both with and without fertilizers. The

Table 4. Dependence of Winter Wheat Yield on
BKP With Natural Irrigation

(1) Республика, экономический район	BKP (баллы) (2)	(3) Урожай (ц/га)	
		без удобр. ний (4)	со NPK (5)
(6) Казахская ССР	12	18.3	26.6
Поволжский район РСФСР (7)	90	28.6	32.6
(8) Сухостепная зона УССР	110	30.3	37.6
Северо-Кавказский район РСФСР (9)	149	38.9	47.6

Key to Table 4:

- | | |
|---------------------------------|--|
| 1. Republic, economic region | 5. With NPK |
| 2. BKP (points) | 6. Kazakh SSR |
| 3. Yield (quintals per hectare) | 7. Volga region of the RSFSR |
| 4. Without fertilizer | 8. Dry-steppe zone of the UkSSR |
| | 9. Northern Caucasus region of the RSFSR |

Table 5. Dependence of Winter Wheat Yield on BKP
With Optimal Moisture Supplies (Irrigation)

(1) Республика, экономический район	BKP (баллы) (2)	(3) Урожай (ц/га)	
		без удобр. ний (4)	со NPK (5)
(6) Поволжский район	150	31.0	52.4
(7) Северо-Кавказский район	176	46.2	58.4
(8) Сухостепная зона УССР	184	40.7	58.7
(9) Казахская ССР	192	42.2	59.6

Key to Table 5:

- | | |
|---------------------------------|---------------------------------|
| 1. Republic, economic region | 6. Volga region |
| 2. BKP (points) | 7. Northern Caucasus region |
| 3. Yield (quintals per hectare) | 8. Dry-steppe zone of the UkSSR |
| 4. Without fertilizer | 9. Kazakh SSR |
| 5. With NPK | 10. RSFSR |

greater return on fertilizer in the GDR is related to the fact that the soil there has greater supplies of phosphorus and potassium and that our studies dealt only with nitrogen fertilizers.

Under the conditions found in the Northern Caucasus (USSR) and in Bulgaria, which belong to the same morphophysiological subtype with regard to winter wheat, the same high level of yield with the utilization of fertilizer was achieved (47.6 and 46.9 quintals per hectare). The return on fertilizer is higher in these countries than in the USSR, which is related to the higher yield levels without fertilizer in the Northern Caucasus as compared with Bulgaria. Within this classification the other rayons in our country do not have analogous regions abroad.

In our country agricultural production is undertaken under very complex and hardly favorable natural and climatic conditions. About 70 percent of our area cannot be used for agriculture and only 28.4 percent is characterized by relatively favorable natural conditions. Of this territory 12.6 percent is southern taiga, 6.9 is forest-steppe and 9 percent is steppe and dry-steppe (4). The southern taiga zone has good supplies of moisture, but insufficient warmth. In the forest-steppe zone the shortage of moisture is already having an effect, and the steppe and dry-steppe regions are characterized by an increased degree of dryness. The regions with an annual precipitation sufficient for effective farming (about 700 millimeters) includes only 1.1 percent of the plowland. Forty percent of the plowland is found in regions of "risky" farming (precipitation is less than 400 millimeters). As regards heat supplies, 60 percent of all plowland is found in regions where the average annual temperature is up to +5°C, i.e. in regions with insufficient supplies of heat.(2). For this reason a comparison of the effectiveness of fertilizer on wheat as well as on other crops can be made only by cultivating it in similar natural and climatic conditions.

Conclusions

In order to study the dependence of the winter wheat yield on climatic conditions it is not enough to utilize individual indicators of climate. The yield of winter wheat can be correlated well with the complex indicator of BKP, which reflects the total of climatic factors as well as the biological productivity of zonal soil types.

The zones and provinces cultivating winter wheat can be categorized according to low, average or high biological productivity when natural water supplies are considered. With the use of mineral fertilizers the yield of winter wheat is 26.5, 34.6 and 43.2 quintals per hectare respectively.

In zones with large supplies of warmth the use of irrigation can create the conditions for high and very high biological productivity, producing yields of up to 60 quintals per hectare with fertilization.

The fluctuation in yield based on changes in weather conditions in climatic zones is significant. The variation coefficient comprises 25-46 percent.

With the use of fertilizer it is possible to decrease the variation coefficient by 5-7 percent; with the simultaneous use of fertilizer and irrigation the yield by years is equalized (variation coefficient of 14, 15 and 19 percent), enabling us to produce relatively stable and large yields.

Table 6. Fluctuation of Winter Wheat Yield (Quintals per Hectare) and the Variation Coefficient According to Zones

(1) Республика, экономический район		(2) Без орошения				(3) При орошении			
		(4) без удобрений		(5) по NPK		(4) без удобрений		(5) по NPK	
		min	max	v %	min	max	v %	min	max
(6)	Полесье	15.2	50.8	25	21.5	88.4	25	—	—
(7)	Лесостепь	10.4	57.5	30	12.3	84.7	25	—	—
(8)	Степь	8.2	62.1	38	13.5	79.8	31	—	—
(9)	Сухостепная зона	7.1	51.6	39	7.8	62.6	37	18.7	89.1
(10)	Центрально-Черноземный район	5.7	49.0	46	10.8	80.2	40	—	—
(11)	Поволжский район	10.7	60.9	42	11.0	56.3	37	18.8	49.9
(12)	Казакская ССР	8.3	38.8	32	10.7	41.5	35	12.7	46.1
								27.5	60.9
								30	87.4

Key to Table 6:

1. Republic, economic region
2. Without irrigation
3. With irrigation
4. Without fertilizer
5. With NPK
6. Poles'ye
7. Forest-Steppe
8. Steppe
9. Dry-steppe zone
10. Central Chernozem region
11. Volga region
12. Kazakh SSR
13. Ukrainian SSR
14. RSFSR

Table 7. Comparative Effectiveness of Fertilizer When Cultivating Winter Wheat in Similar Climatic Conditions in the USSR and Abroad

Место проведения опыта (1)	Число опытов (2)	(3) Урожай (ц/га)		Продукция (ц/га) (6)	(7) Удобрения в среднем в год			Одностороннее и с N, P, K NPK при- роста (ц)
		без удобрений	с NPK		N	P ₂ O ₅	K ₂ O (8) сумма	
СССР (Ленин) (10)	29	(4) 33.1	(5) 48.3	12.1	72	70	46	188 6.4
ГДР (11)	34	39.7	50.9	14.1	114	—	—	116 12.4
СССР (Северный Кавказ) (12)	143	38.9	47.6	8.7	62	77	33	172 5.1
СФРЮ с NPK (13)	62	30.6	46.9	16.4	112	85	31	228 7.1

Note. The data on Yugoslavia and Bulgaria was prepared by Z. K. Blagoveshchenskaya.

Key to Table 7:

1. Location of tests
2. Number of tests
3. Yield (quintals per hectare)
4. Without fertilizer
5. With NPK
6. Increase (quintals per hectare)
7. Fertilizer, annual average
8. Total
9. Return on 1 kilogram of active substance of NPK in terms of increase (kg)
10. USSR (Lithuania)
11. GDR
12. USSR (Northern Caucasus)
13. Yugoslavia and Bulgaria

The yield of winter wheat and the effectiveness of fertilizers in our country can be compared to those abroad only for groups of wheat of one morphophysiological type or subtype whose distribution is related to certain soil and climatic conditions.

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RECOMMENDATIONS FOR EFFECTIVE USE OF MANUFACTURED FERTILIZERS ON YIELDS

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[Article by R. A. Srapenyants, candidate of engineering sciences, A. I. Novikov, I. M. Strebkov, L. Z. Shapiro and Ya. T. Kirikoy, candidate of agricultural sciences, All-Union Scientific Research Institute of Fertilizers and Soil Science imeni D. N. Pryanishnikov (VIUA); submitted 22 May 1980]

[Text] It is a most important task of research in agricultural chemistry to issue recommendations for effective use of manufactured fertilizers that will guarantee the planned yields of agricultural crops in various soil-climate zones. The number of methods of calculating rates of fertilizer application is so sizable that it is a complicated matter to determine optimum amounts of fertilizers. Abundant experimental data have accumulated on field experiments with fertilizers for a number of crops which reflect the empirical relationships of the effect of rate of fertilizer application on the yield under different conditions of soil and climate. The task consists of summarizing these data by means of mathematical methods and of building models that take into account the principal quantitative and qualitative patterns of effect of fertilizers and other factors on the yield.

The most widespread are continuous models which describe the polynomial dependence of the yield on fertilizers. In the final stage all models are subjected to experimental verification. But certain difficulties are involved in the use of models in practice, since the more complicated the model and the more accurately it describes all the phenomena in the set of input information under consideration, the higher the requirements this model must meet with respect to the amount and quality of input information.

Recently models have been built which are based on linear functions of plant response to rates of fertilizer application. For instance, Swanson [21] developed a model on the basis of the law of the minimum, which postulates linear dependence of response on the principal limiting element, which suddenly breaks down when other factors become the limiting ones, but

recovers linearity when the constraints are adjusted. Boyd [18], who summarized a large amount of data on various crops, showed that they conform quite well to a model of the Liebig type. Bartholomew [17], who summarized data on response to nitrogen, drew the conclusion that response is best described by a piecewise-linear function consisting of a linear (sloping) segment and a horizontal segment (plateau). This assessment reflects the biological optimum, that is, the minimum rate of fertilizer application necessary to obtain the yield at the plateau. The models of the yield pattern which Galot created for FAO [17] are built on the quadratic dependence of the yield on fertilizer, and the effect of each type of manufactured fertilizer is considered independent.

These approaches to solving the problem were based on knowledge of simple single-factor functional relationships. But we need not only to discover the influence of the particular factor on the yield, we also need to study the entire diversity of their interaction. If possible all factors influencing the yield should take part in the model. Only multifactor models can fully represent the nature of the phenomena being studied.

The principal stages in building the model are these: shaping the initial sample of experimental data; selection of the factors to be included in the models; preliminary statistical processing of these data, including dispersion, correlation and factor analysis; selection of the type of model and building the model of the yield pattern; and checking the model's appropriateness. Following these stages a calculation must be made of optimum rates of fertilizer application for the yield that is planned on the basis of the model that has been built. We will examine the stages of building a model we have enumerated.

Forming the sample of experimental data as a source of information on the general population is always the essence of one of the basic questions of modelbuilding. Every sample is a source of information on the general population; it will be representative if it correctly reflects all the typical peculiarities of the general population. If this is to be achieved, all possible categories of events must be represented in the sample in approximate proportion to the probability of these events in that population.

In the general case the principal condition for obtaining a representative sample is random selection of subjects for study. It is equally important to have a sample of such size that it reflects the principal peculiarities of the general population. In practice when a researcher is summarizing, he usually encounters a paucity of experimental material and in these cases is forced to take virtually all the material accumulated on the given question to compile his sample.

Thus the size of the sample and the character of the information included in it are for all practical purposes determined by posing the problem of a studying involving summarization and by the information that is available on the question being studied. Starting from the goal of the summarization

and a thorough analysis of the experimental data, the researcher, relying on concrete knowledge of the phenomenon being studied, makes a selection of the factors which are to be taken into account in building the model of the yield pattern. In summarizing the data of field experiments in order to determine the patterns of influence of manufactured fertilizers on the yield, in our research we took under consideration factors which determine the condition of the subject of the research with the necessary completeness: the amounts of fertilizer to be applied, the characteristics of soil fertility and meteorological data. These factors can be divided into four groups:

first-- $t_p = (pH, P_2O_5, K_2O, \Gamma, \Phi\Gamma)$ --factors of soil fertility (here Γ is the content of humus, and $\Phi\Gamma$ the mechanical composition of the soil). Information on the values of the factors in this group was obtained as a result of laboratory analyses of the soil; these factors can be monitored;

second-- $t_2 = (N, P, K)$, that is, those controllable factors characterized by the amounts of fertilizer applied;

third-- $t_g = (CO, CT)$ --the group of weather conditions; CO --total precipitation, and CT --the sum of active temperatures during the period of vegetation. The factors in this group are not controllable under natural conditions of plant growth and development, and the most complicated matter is to express meteorological conditions in quantitative terms.

The vegetative period can be divided into a series of subperiods within which temperature changes and the amount of precipitation have an unequal influence on formation of the yield, but introducing into the model a large number of indicators reflecting weather conditions gives rise to a number of adverse phenomena in devising the regression equation. In order to reduce the number of these factors it has been proposed by some authors that they be expressed by total precipitation and total active temperatures during the period of the most intensive plant growth or even by a single indicator--the coefficient of weather conditions, which would characterize the total influence of precipitation and air temperature in the critical periods of plant growth [1, 3, 15, 16]. None of these approaches claim to have definitively solved the problem of the most effective way of expressing weather conditions; it needs further study;

fourth-- \hat{Y} --the yield, which is characterized by the experimental values of the yield pattern (with repetitions) of agricultural crops.

The model-building problem is to construct from the experimental values of the factors included in the groups a function of the yield Y that depends on the factors of the first three groups so that the theoretical values of the yield Y approach as much as possible its experimental values \hat{Y} obtained in field experiments with fertilizers.

As data on field experiments with fertilizers increase and the knowledge of agricultural chemistry grows, it is possible to increase the number of factors called upon in determining the condition of the subject of the study and to broaden their classification. Then the question arises of evaluating the significance of the variable x , comprised of the values of the factors. The number of values included in a quadratic 10-factor model turns out in the general case to be rather large (66 parameters), but they are not all equally important. The excessive number of variables may make a contribution to the model of the yield out of proportion to their significance, thereby distorting expression of the pattern of the phenomenon being studied. It becomes necessary to select from the initial variables a certain set of them which includes the variables that are most essential to solving the problem that has been set. Some of the parameters are excluded on the basis of a priori knowledge which agricultural chemistry has of the phenomenon being studied and of the value of correlations between the initial experimental values of the yield and the variables of the model, even before the stage of building the model.

In order to verify the correctness of shaping the sample and in order to select the factors, the initial data undergo preliminary processing, which includes dispersion analysis and correlation analysis. The former analysis is built on the supposition that in every fixed set of values of the factors in the first three groups the yield has normal distribution, and its dispersion among all the gradations of the factor being studied is homogeneous [10]. In practice the condition of normal distribution is not very rigid, but the condition of homogeneity of dispersion must be strictly fulfilled. Fulfillment of the condition of homogeneous dispersion is checked by means of Bartlett's and Cochran's criteria [20]. Dispersion analysis comes down to breaking down the total dispersion σ^2 into its components and of comparing them in order to evaluate the influence of the factors on the value of the resultant characteristic. Therefore

$$\sigma^2 \cdot (N-1) = \sigma_f^2 \cdot (a-1) + \sigma_b^2 \cdot (N-a), \quad (1)$$

in which σ_f^2 --dispersion introduced by the influence of the factors; σ_b^2 --dispersion of reproducibility; N --number of experiments; a --number of gradations of the factor.

The significance of the influence of the factors is ascertained by means of Fisher's criterion. The dispersions σ_{ib}^2 , which correspond to different i -th dispersion complexes, are checked as to whether they belong to one common sample. If homogeneity of the individual dispersion complexes is established by means of these criteria, the total error of the experiment, including the k of the dispersion complexes, is equal to

$$\sigma_e = \sqrt{\sum_i \sigma_{ib}^2 \cdot (N_i - 1) / \sum_i (N_i - k)}. \quad (2)$$

in which N_i --size of the i -th complex.

Dispersion of the total sample with f_0 degrees of freedom is determined by the value σ_0^2 .

The next stage in preliminary processing of the information is to conduct correlation analysis [4], which makes it possible to obtain a general idea of whether there is a relation between the characteristics and the closeness of that correlation, as the first stage in studying the mutual variability of the characteristics. Tables are compiled of paired correlations of factors being studied and also of each of them with its resultant characteristic. Only those factorial characteristics which do not have a close correlation with one another, but display reliable correlation to the resultant characteristic, are included in the model as characteristics to be studied.

Then multiple regression analysis is used to determine the quantitative dependence among the values of the characteristics. The capacity of the immediate access memory of the computer and the amount of information to be processed are essential in selecting the algorithm for building the model. In our work we used the method of statistical regression; moreover, all the information was not simultaneously introduced into the computer's immediate access memory, but rather it was read in in portions to form a covariance matrix of observations, which allows one to process information in virtually any amount.

In the general case the functional relationship between the yield and the vector of input factor t takes the form $Y = f(t)$. Polynomial models are most often used in building models of the effect of fertilizers on yield because polynomials can approximate an analytical function $f(t)$ with any degree of accuracy. But as the degree of the polynomial increases, the number of parameters of the model increases substantially, and the requirements as to the amount of initial information are correspondingly higher. Taking the available data as our point of departure, we built models of the yield in the form of a second-degree polynomial of k input factors t

$$Y = \beta_0 + \sum_{i=1}^k \beta_i \cdot t_i + \sum_{i,j=1}^k \beta_{ij} \cdot t_i \cdot t_j. \quad (3)$$

Here β --parameters of the model, t --values of the factors under consideration. Equation (3) can also be represented in this form:

$$Y = Xb, \quad (4)$$

if by X we mean the matrix of variables made up of the values of the factors t , while b refers to the parameters of the model being studied.

Let X and \bar{Y} be centered and normed initial data. The expanded variance matrix of observations $\theta = \begin{pmatrix} 1 & \bar{S}^T \\ -\bar{S} & Q \end{pmatrix}$, which consists of central moments of second order of the input data [14]. Here $Q = X^T \cdot X/N$ --the normed covariance matrix formed of the matrix of observations X of the sample being

studied, whose size is N ; $S = X^T \cdot \bar{Y}/N$ —vector of correlation coefficients between the input variables X and the observed values of the yield \bar{Y} . Thus the elements of the matrix Q and of the vector S determine the matrix G with the elements (G_{ik}) , $(i, k, k = 1, \dots, n+1)$. Its determinant is referred to as the generalized dispersion of $(n+1)$ -dimensional distribution. The correlation coefficients

$$r_{ik} = G_{ik} / \sqrt{G_{ii} \cdot G_{kk}} \quad (5)$$

determine the correlation matrix (r_{ik}) of the $(n+1)$ -dimensional distribution provided all $G_{ii} \neq 0$; here n is the number of parameters of the model.

Using the symmetrical nature of the matrix G , only its portion over the main diagonal is computed and stored in the computer memory. In addition, the matrix G is rotated by the square root method. The coefficients of the model b are expressed by the elements of the matrix $\Lambda = G^{-1}$ as follows:

$$b_i = -\Lambda_{i,n+1} / \Lambda_{n+1,n+1}, \quad (i = 1, \dots, n). \quad (6)$$

The residual dispersion is

$$\sigma_b^2 = 1 / \Lambda_{n+1,n+1}. \quad (7)$$

The dispersion of the coefficients of the model is

$$D(b_i) = Q_{ii}^{-1} \cdot \sigma_b^2, \quad (i = 1, \dots, n). \quad (7a)$$

The absolute term is computed from the formula:

$$b_0 = \frac{\sum_{i=1}^N \left(\bar{Y}_i - \sum_{j=1}^n b_j X_{ij} \right)}{N}. \quad (7b)$$

The appropriateness of the model to the experimental data is evaluated with respect to the multiple correlation coefficient R , which reflects the degree of closeness between the theoretical values of the yield Y and the experimental values \bar{Y} :

$$R = Y^T \bar{Y} / N \sigma(Y), \quad (8)$$

in which $\sigma(Y)$ —standard deviation of Y .

In the algorithm proposed the multiple correlation coefficient is calculated from the formula:

$$R = \sqrt{1 - \sigma_b^2 / G_{n+1,n+1}}. \quad (9)$$

Dispersions of the parameters of the model b were determined, and the insignificant parameters were rejected (stepwise regression).

We take advantage of the obvious relationship $(Y - \hat{Y})^T \cdot Y = 0$, which reflects the independence of the theoretical yield and the lack of linkage between the experimental and theoretical yield. Having divided this relation by N and removing the parentheses, we get $R_0(Y) = \sigma^2(Y)$, so that we have this:

$$R^2 = Y^T X \cdot b / N = S^T \cdot b = b^T Q \cdot b. \quad (10)$$

The quantity R^2 (the coefficient of determination) evaluates that portion of the parameter \hat{Y} which results from the existence of the linear relationship between \hat{Y} and the input variables.

We will clarify the meaning of expression (10). The share of the i -th parameter in building the model of the yield is measured by its contribution to the coefficient of determination and is represented as the i -th member of a scalar product:

$$V_i = (S^T \cdot b)_i = S_i \cdot b_i = \sum_j Q_{ij} \cdot b_i \cdot b_j. \quad (11)$$

in which Q_{ij} --elements of the matrix Q .

We call attention to the fact that the contribution V_i can be divided into two parts

$$V_i^{(1)} = b_i^2 = V_i^{(n)} = \sum_{j \neq i} Q_{ij} \cdot b_i \cdot b_j;$$

$$V_i = V_i^{(1)} + V_i^{(n)}.$$

The quantity $V_i^{(1)}$ characterizes the i -th parameter's own contribution to the model (direct contribution). The quantity $V_i^{(2)}$ determines the contribution of the i -th parameter to the model by virtue of its interaction with the other input parameters of the model (the mediated contribution). Thus $V_i^{(2)}$ indicates that portion of the i -th parameter's contribution to the model which can bind the other parameters of the model to itself when the parameter b_i is excluded from consideration. In evaluating the substantiality of a particular parameter, then, we should take into account the relationship of that parameter's direct and mediated contribution to the model, specifically: a smaller contribution is made to the model by the parameter which has a smaller direct contribution and a larger mediated contribution.

The predicted value of the yield obtained on the basis of the model which has been developed is determined at the point x_p as

$$Y_p = x_p \cdot b. \quad (12)$$

The dispersion of the predicted yield is determined by the expression:

$$D(Y_F) = x_F^T \cdot D(b) \cdot x_F \cdot \sigma_y^2 \quad (13)$$

We use $\sigma_y = \sigma_3$ as the measure of the dispersion of the level of the yield; it characterizes the accuracy of the experiments (with f_3 degrees of freedom, which is related to the size of the sample N and the number of repetitions in each experiment). But in conventional regression analysis a different measure of the dispersion $\sigma_y = \sigma_0$ is used; it characterizes the inaccuracy of description of the experimental data by the calculated regression equation (whose number of degrees of freedom is $f_0 = N - l - 1$, in which l is the number of regression coefficients without an absolute term).

It is possible to take into account σ_3^2 and σ_0^2 at the same time; provided the model is appropriate, and they are unbiased estimates of one and the same quantity--the general dispersion σ_y^2 . The absence of systematic discrepancies between σ_3^2 and σ_0^2 , checked with respect to F--Fisher's criterion:

$$F = \sigma_0^2 / \sigma_3^2 \leq F_T(\alpha, f_0, f_3) \quad (14)$$

with the given reliability α , does not disprove the hypothesis of the validity of this type of model. It is proposed that the estimate σ_y^2 be found whose number of degrees of freedom is $f_y = f_0 + f_3$:

$$\sigma_y^2 = (f_0 \cdot \sigma_0^2 + f_3 \cdot \sigma_3^2) / f_y \quad (15)$$

Thus the expressions (12), (13) in the case of the appropriateness of the model, checked by formula (14), determine the predicted value of the yield with its dispersion in the polynomial model at any point of multifactor k -dimensional space.

We will examine the stages of modelbuilding through a specific example of summarizing experimental data. Assume we need to determine the patterns of effect of manufactured fertilizers on loamy sod-podzolic soils of the Central Region of the Nonchernozem Zone of RSFSR as a function of the level of current soil fertility and weather conditions on the grain yield of spring barley.

The work begins with the shaping of the sample, for which purpose an instruction is issued to select from the experimental data bank experiments studying the effect of fertilizers on loamy sod-podzolic soils of this region on the yield of the spring barley variety Moskovskiy 121.

One of the most complicated problems in modelbuilding when a problem is set up this way is choosing the factors. On the one hand we want to cover as fully as possible all the factors of the environment with which the rates of fertilizer application interact in influencing the yield of barley, while on the other there is the danger of a mechanical generalization of a large number of factors, which inevitably results in a scattering of the influence and of the significance of each of them and could lead to an error concerning each factor's true contribution to the yield.

As a result of a detailed preliminary analysis of the experimental data, based on concrete knowledge of the causal nature of the phenomenon being studied, a selection is made of a limited number of factors which would reflect with sufficient completeness the relationship of the fertilizers to the soil properties, moisture and heat. It was decided in this case to express the level of soil fertility by indicators of the content of mobile forms of phosphoric acid in the soil, metabolic forms of potassium, and the reaction of the soil medium pH_{KCl} , the content of physical clay (mechanical composition), the humus content (humus according to Turin), and the weather conditions--total precipitation over the vegetative period and the sum of average daily temperatures higher than $+10^{\circ}\text{C}$ over the same period.

The sample was thoroughly checked for the completeness of the information: every measurement of the yield had to be accompanied by current measurements of the factors being studied. Experiments in which the information was not complete were dropped from the sample. After a thorough analysis and rejection of incomplete information, the sample in this particular case consisted of 1,200 measurements of yield with corresponding measurements of the accompanying factors (71 experiments by more than 20 institutions).

An analysis of paired correlation between the factors and also between the yield and the values of the factors being studied showed absence of a close internal correlation between the factors and a reliable correlation of each factor to the yield, which made it possible to consider a regression equation of second order in which these factors participate as a model of the phenomenon being studied.

The low variability of the indicator of humus in the experiments (1.9-2.2) made it possible to eliminate this factor from the model without a loss of significance of the regression equation as a whole. The multiple correlation coefficient was 0.848 before this factor was eliminated and 0.843 afterward. An analysis of the contributions of the regression coefficients to the model also made it possible to eliminate a number of coefficients with insignificant contribution of their own (less than 0.05) without noticeable damage to the significance of the equation.

Rejection of statistically insignificant coefficients made it possible to reduce the number of terms in the equation to 24 with a multiple correlation coefficient of 0.84, an error of reproducibility of 2.8 quintals per hectare, and a coefficient of determination 0.71.

Table 1 gives the calculated values of the barley yield as a function of increasing amounts of nitrogen, phosphorus and potassium fertilizers against the background of fixed optimum values of the indicators of soil fertility and weather conditions. The level of content of mobile P_2O_5 in the soil was taken at a comparatively low level (5 mg per 100 g of soil according to Kirsanov) so that the effect of the amounts of phosphorus fertilizers was manifested rather distinctly. The effect of the amounts of phosphorus fertilizers at higher saturation of soils by mobile forms of phosphoric acid is represented in a separate table.

Table 1. Dependence of the Yield of Spring Barley Grain on Rates of Application (kilograms per hectare of active ingredients) and the Proportions of Manufactured Fertilizers at pH = 5.8, P_2O_5 = 5, K_2O = 17, CO = 260 mm (total precipitation over the vegetative period) and CT = 1,600° C (sum total of temperatures higher than +10° over that same period). The notation is the same in the subsequent table

N	P	K				
		0	40	80	120	160
0	0	18.0	22.4	24.7	24.9	23.0
	60	18.6	23.6	26.4	27.1	25.8
	120	18.9	24.3	27.7	28.9	28.1
	180	18.8	24.7	28.8	30.7	30.6
40	0	24.7	29.4	31.9	32.3	30.7
	60	25.6	30.8	33.8	34.8	33.7
	120	26.1	31.8	35.4	36.9	36.3
	180	26.1	32.6	36.8	39.1	39.2
80	0	28.2	33.1	35.9	36.6	35.2
	60	29.3	34.8	38.1	39.3	38.4
	120	30.1	36.1	39.9	41.7	41.3
	180	30.5	37.2	41.7	44.2	44.6
120	0	28.5	33.6	36.7	37.6	36.4
	60	29.9	35.6	39.3	40.6	40.0
	120	31.0	37.2	41.3	43.3	43.2
	180	31.7	38.6	43.6	46.2	46.8
160	0	25.6	31.0	34.3	35.8	34.6
	60	27.3	33.2	37.1	38.8	38.4
	120	28.6	36.1	39.4	41.7	41.8
	180	29.8	36.9	42.0	45.0	45.8

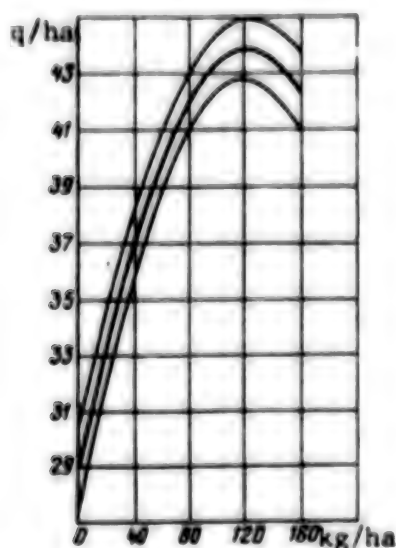


Figure 1. Influence of increasing amounts of nitrogen fertilizers (kilograms per hectare of active ingredients) on the barley yield at optimum values of other growth factors (P--140; K--120; pH--5.8; P_2O_5 --15 mg per 100 g of soil; K_2O --17 mg per 100 g of soil; Φ --physical clay, 35 percent; Γ --humus, 2 percent; CO--total precipitation, 260 mm, and CT--total active temperatures, 1,600° C over the vegetative period). The notation is the same used in Figures 2, 3, 4 and 7.

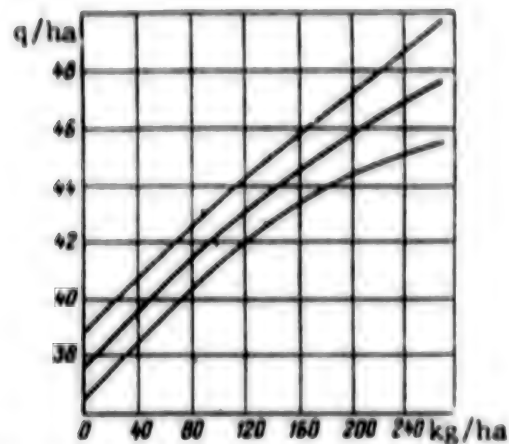


Figure 2. Influence of increasing rates of application of phosphorus fertilizers (kilograms per hectare of active ingredients) on the barley yield at the optimum values of other growth factors (N--120, K--120, pH--5.8; P_2O_5 --15, K_2O --17, ΦT --35, Γ --2, CO--260, CT--1,600).

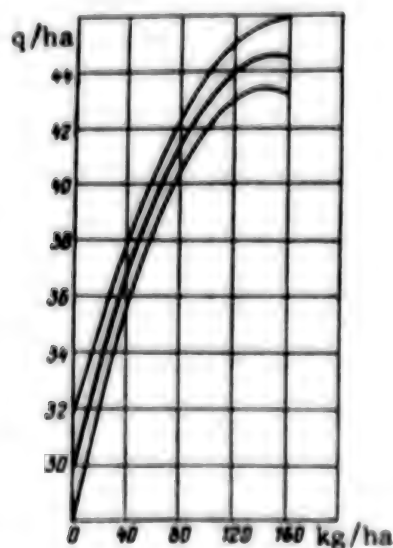


Figure 3. Influence of increasing rates of application of potassium fertilizers (kilograms per hectare of active ingredients) on the barley yield at the optimum values of other growth factors (N--120, P--140, pH--5.8; P_2O_5 --15, K_2O --20, ΦT --35, Γ --2, CO--260, CT--1,600).

It is evident from the data in Table 1 that the maximum yields of barley were obtained at rates of 120 kg of nitrogen fertilizers and 120 and 160 kg per hectare of active ingredients of potassium fertilizers. The difference in significance of the yield of the 120- and 160-kg-per-hectare doses of potassium fertilizers lies within the limits of the statistical error. Application of increasing amounts of phosphorus fertilizers without adding

nitrogen and potassium fertilizers was not accompanied by a greater yield because nitrogen is the first minimum that must be met in the soil. Nitrogen fertilizers applied unilaterally increased yields from 18 to 28 quintals per hectare, and potassium fertilizers increased it from 18 to 25 quintals per hectare. With respect to the latter we should note that increasing amounts of potassium are very effective all the way to 120 kg per hectare of active ingredients in spite of the quite high content of metabolic potassium in the soil (17 mg per 100 g of soil).

Table 2. Effect of Increasing Amounts of Nitrogen Fertilizers on the Grain Yield of Spring Barley at P = 120, K = 140, pH = 5.8, P_2O_5 = 5, K_2O = 17, CO = 260 and CT = 1,600

<u>Kg/ha of Active Ingredients</u>	<u>Q/ha</u>
0	28.8
25	34.0
50	38.0
75	39.6
100	41.8
125	42.8
150	42.0

Table 3. Effect of Increasing Amounts of Phosphorus Fertilizers on the Grain Yield of Spring Barley at N = 120, K = 140, pH = 5.8, P_2O_5 = 5, K_2O = 17, CO = 260 and CT = 1,600

<u>Kg/ha of Active Ingredients</u>	<u>Q/ha</u>
0	36.7
40	39.2
80	41.5
120	43.6
160	45.5
200	47.3

Table 4. Effect of Increasing Amounts of Potassium Fertilizers on the Grain Yield of Spring Barley at N = 120, P = 140, pH = 5.8, P_2O_5 = 5, K_2O = 17, CO = 260 and CT = 1,600

<u>Kg/ha of Active Ingredients</u>	<u>Q/ha</u>
0	31.7
25	35.8
50	39.1
75	41.6
100	43.3
125	44.3
150	44.2

Table 5. Influence of the Reaction of the Soil Medium on the Efficiency of Manufactured Fertilizers Applied to Spring Barley at $P_2O_5 = 5$, $K_2O = 17$, $CO = 260$ and $CT = 1,600$

<u>pH_{KCl}</u>	<u>Rates of Application of NPK (kg/ha of ac- tive ingredients)</u>	<u>Yield (q/ha)</u>
4.1	40- 60- 40	27.7
	80-100- 80	35.5
	120-140-120	38.5
5.0	40- 60- 40	29.8
	80-100- 80	36.1
	120-140-120	39.9
6.0	40- 60- 40	30.2
	80-100- 80	39.4
	120-140-120	45.4
6.4	40- 60- 40	31.3
	80-100- 80	42.0
	120-140-120	48.8

The effect of potassium in combination with nitrogen is especially vigorous: when nitrogen-potassium fertilizers are applied together, the barley yield increases to 37-38 quintals per hectare. Against this background increasing amounts of phosphorus fertilizers also become effective, adding as much as 8-10 quintals per hectare to the yield.

The total grain yield of spring barley when nitrogen was applied at rates of 100-120 kg per hectare of active ingredients, phosphorus at the rate of 120-140 kg per hectare and potassium at the rate of 120-140 kg per hectare reaches 45-50 quintals per hectare (Figures 1, 2 and 3; Tables 2, 3 and 4). The reaction of the soil medium, expressed by the concentration of hydrogen ions in the soil solution, is one of the essential factors exerting a many-sided influence on the conditions for formation of the yield and on the level of efficiency of fertilizers (Table 5).

Barley is a crop that is sensitive to the reaction of the soil medium; it develops better on slightly acidic or neutral soils, at a pH between 4 and 5 the efficiency of fertilizers changes little, increasing substantially in the pH interval from 5 to 6.4. In the first case the yield rises at optimum rates of application from 38.5 quintals per hectare to 39.9 quintals, in the latter from 39.9 quintals per hectare to 48.8 quintals. On sod-podzolic loamy soils the dependence of the yield on the pH against the background of complete fertilization is expressed in 0.6 quintal per hectare per 0.1 pH unit. It is thus not possible to obtain a barley grain yield on the order of 45-50 quintals per hectare on acid soils which have not been limed, but it becomes possible on weakly acidic or neutral soils against a background of optimum rates of application of manufactured fertilizers (Figure 4).

It can be taken as established that the efficiency of phosphorus fertilizers is closely correlated to the saturation of soils with mobile forms of phosphorus, and therefore on soils well supplied with assimilable phosphates, additionally applied phosphorus fertilizers are not accompanied by substantial additions to the yield [7, 8, 9, 11, 12].

Table 6 gives the data of the generalization reflecting the efficiency of phosphorus fertilizers applied to spring barley as a function of the saturation of soils with mobile forms of phosphorus.

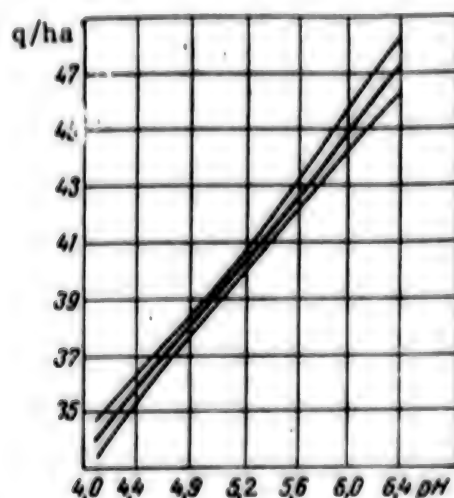


Figure 4. Influence of soil acidity on the barley yield at optimum values of other growth factors (N--120, P--140, K--120, P_2O_5 --15, K_2O --20, $\Phi\Gamma$ --35, Γ --2, CO--260, CT--1,600)

Table 6. Efficiency of Phosphorus Fertilizers Applied to Spring Barley as a Function of Saturation of Soils With Mobile Forms of Phosphorus at pH 5, N 100, K 100, K_2O 15, CO 260 and CT 1,600. The level of probability is 0.95

Mobile P_2O_5 (mg/100 g)	Rates of Application of P (kg/ha of active ingredients)				
	0	60	90	120	150
1	33.1	36.2	37.5	38.9	40.0
5	34.3	36.9	38.1	39.1	40.1
10	35.6	37.7	38.6	39.4	40.1
15	37.0	38.0	39.0	39.7	40.1
20	38.0	39.2	39.5	39.9	40.1
30	40.1	40.3	40.2	40.1	40.0

It is evident from the figures in Table 6 that as the content of mobile P_2O_5 in the soil increases, the average barley yields also increase at a rate of 0.2-0.3 quintal per hectare for every increase by 1 mg per 100 g of soil. When the content of mobile phosphorus in the soil is high, a

yield on the order of 40 quintals per kilogram can be obtained even without applying phosphorus fertilizers, using only nitrogen-potassium fertilizers.

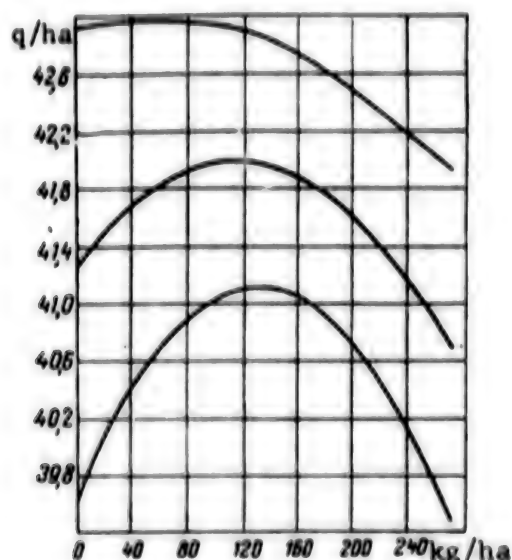


Figure 5. Effect of increasing rates of application of phosphorus fertilizers (kilograms per hectare of active ingredients) on the barley yield when soils were well supplied with mobile phosphorus (P_2O_5 according to Kirsanov, 15 mg per 100 g of soil).

When the content of mobile phosphorus is low or average (up to 10 mg per 100 g of soil), moderate doses of phosphorus fertilizers up to 100-120 kg per hectare of active ingredients yield a statistically reliable addition of 6-8 quintals per hectare of grain.

But as soon as the content of mobile phosphates is 15 mg of 100 g of soil or higher, additionally applied phosphorus fertilizers do not yield a statistically reliable addition to the barley yield (Figure 5). This agrees with the well-known studies of VIUA in which the optimum level of the content of mobile P_2O_5 in sod-podzolic soils of the Nonchernozem Zone of RSFSR was determined (10-15 mg per 100 g of soil), the content at which additional phosphorus fertilizers do not result in a larger yield of crops [11]. When the content of mobile P_2O_5 in the soil is low, additionally applied phosphorus fertilizers ensure a statistically reliable growth of the yield (Figure 6).

Increasing the content of metabolic forms of potassium has little effect on the yield of barley (Table 7). Dependence of the effect of potassium fertilizers on the saturation of the soil with metabolic potassium was not observed in the experiments: even at a high content additional potassium fertilizers have notable efficiency (Table 8).

The weather conditions of the vegetative period (moisture and heat) have such a strong influence on the development of plants, that in years with extreme values of moisture and total temperature that deviate greatly from the average values over many years, the manufactured fertilizers applied have no positive effect at all on the yield or tend to diminish it. The factor of precipitation during the vegetative period was manifested quite sharply in our generalization, substantially determining the size of the yield. Table 9 gives data for the 1968-1978 period on the influence of precipitation against the background of optimum rates of application of fertilizers on the yield of barley in the Central Region of the Nonchernozem Zone of RSFSR: this factor alone more than doubled it (Figure 7).

On the basis of the model built of the yield pattern for a given crop it is possible to determine the optimum rates of application of manufactured fertilizers for the planned yield using the methods of nonlinear programming solving the problem of finding the maximum of the functional:

$$\Phi(t_2) = C_1 \Delta Y_{pe}(t_2) - C_2 \cdot t_2 \quad (21)$$

for the constraints $Y = Y_{nn}$, $\min t_2 \leq t_2 \leq \max t_2$, in which $\Delta Y_{pe}(t_2)$ --addition to the yield from administering chemical fertilizers t_2 under given soil (P) and climatic (E) conditions; C_1 , C_2 --unit prices of the harvest and fertilizers, respectively; Y_{nn} --planned yield.

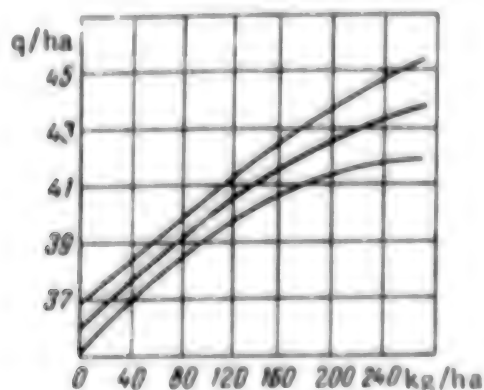


Figure 6. Effect of increasing amounts of phosphorus fertilizers (kilograms per hectare of active ingredients) on the yield of barley for low mobile phosphorus in the soil (P_2O_5 according to Kirsanov, 5 mg per 100 g of soil).

The amount of precipitation and heat can be expressed by looking to the average conditions over a long period of time. In this connection we can say that every crop should be calculated for deviations of weather conditions in one direction or another from the average level over a lengthy period. If long-range weather forecasts are reliable enough, recommendations for calculation of optimum rates of application of fertilizers can be more accurate.

Table 7. Effect of Soil Saturation With Metabolic Forms of Potassium on the Efficiency of Manufactured Fertilizers for Spring Barley at N = 120, P = 140, pH = 6, P₂O₅ = 15, CO = 260 and CT = 1,600

<u>K₂O (mg/100 g of soil)</u>	<u>Yield (q/ha)</u>
4	40.1
8	42.2
12	43.8
16	45.8
20	46.3
24	46.4
28	46.1

Table 8. Efficiency of Potassium Fertilizers on Soils Differing in the Saturation With Metabolic Potassium at N = 120, P = 140, P₂O₅ = 15, pH = 6, CO = 260 and CT = 1,600

<u>K (kg/ha of ac- tive ingredients)</u>	<u>Metabolic Potassium (mg/100 g of soil)</u>	<u>Yield (g/ha)</u>
9	10	33.8
	20	35.9
60	10	41.7
	20	42.9
120	10	43.5
	20	45.5

Table 9. Influence of Precipitation During the Vegetative Period on the Yield of Spring Barley at Optimum Value of the Other Factors: N = 120, P = 140, K = 120, pH = 6.4, P₂O₅ = 15, K₂O = 20 and CT = 1,600

<u>Total Precipitation (mm)</u>	<u>Q/ha</u>
140	23.1
170	33.5
200	41.1
230	45.9
260	48.1
290	47.5

A number of authors propose that in determining rates of fertilizer application one start not with the size of the yield, but with the conditions for obtaining the maximum average income related to possible fluctuations in weather conditions in the year being planned. It is mathematically possible to select a value of the expression of weather conditions at which the average value of losses resulting from fluctuations of the uncontrollable factor will be minimal [2, 5, 6]. Introducing the prices C₁, C₂

ensures that there will be only one solution to the problem. Use of an economic criterion and solving the relevant optimization problem are a very widespread method of obtaining the values of optimum rates of fertilizer application, as shown by the experience of FAO [17]. But in these cases the effects of the various types of fertilizers on the yield were regarded as independent, which tends to separate the variables and makes it necessary to find the maximum of the quadratic function of one variable. This approach simplifies the computations, but diminishes the quality (appropriateness) that the models obtained and of the rates of fertilizer application calculated from them, since interactions among the various factors are not taken into account.

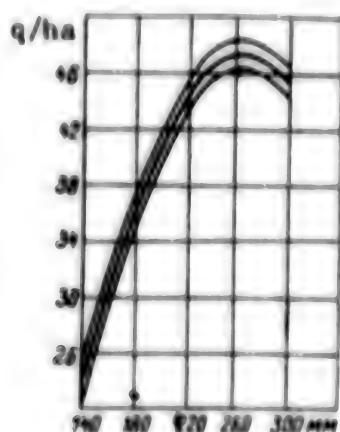


Figure 7. Influence of total precipitation during the vegetative period on the yield of barley at optimum values of the other growth factors (N--120, P--140, K--120, pH--6, P_2O_5 --15, K_2O --20, ΦI --35, Γ --2, CO--260, CT--1,600).

A complete solution to the problem is obtained by means of the systems approach. The computerized information retrieval subsystem (IPS) "Agricultural Chemist of the Geological Network of VIUA" [13], developed at VIUA, reads in, checks, stores, retrieves and performs primary processing on information concerning field experiments with fertilizers. The data can be processed in the IPS according to two procedures: direct communication with the user and delivery of the information required in the form of summaries and connection of the IPS to computational methods and models of the yield of agricultural crops. The system for computer computation of models of the yield ensures the building of regression models of the yield of agricultural crops as the function of various factors [14]. Optimum rates of application of manufactured fertilizers for the planned yield are determined by means of the methods of nonlinear programming on the basis of the model of the yield chosen for the given crop in a unit of the system for computation and for issuing recommendations.

The recommendations drafted for determination of optimum rates of fertilizer application under given soil conditions are checked in production

experiments in the fields of the experimental stations of the VILVA network. The results of production and plot experiments and also the data of laboratory analyses of soils supplement the data base of the IPS, which is used to revise the models of the yield. The entire system is controlled and operated by computer.

The efficiency of manufactured fertilizers when applied according to optimum plans, which have been calculated by means of the models built on the basis of the systems approach, increases, as shown by the experiments, 10-15 percent.

The statistical description of the process does not satisfy us in making forecasts of the yield and fertilizer needs in the future. It is not the development of the process on the average which we need to know, but the tendency in its development at a particular moment. Adaptive models in which a particular time series, which represents a set of observations taken successively in time, is the principal information for the forecast could serve as an instrument in such a forecast. The feature that distinguishes adaptive models from others is that they reflect the current characteristics of the series and are able to continue to take into account the evolution of the dynamic characteristics of processes being studied. Forecasting by the method of extrapolation of ordinary regression curves already contains an element of adaptation. With each new arrival of data from field experiments with fertilizers the parameters of the regression curves are recomputed, and over a sufficiently long time interval even the type of curve could be replaced. But here the degree of adaptation is negligible, since no accounting is made of the contribution of the initial information to the model as a function of how long ago it was obtained, and old data could distort the present picture.

The value of information as a function of time can be taken into account by means of geometrically descending weighting coefficients, which ensures a better approximation of the regression curve to new data.

In the adaptive model of the yield we have developed, the additional factor of time is introduced into the regression equation in its interaction with the parameters of the group t_x --amounts of fertilizers applied and the group t_p --indicators of soil fertility. In the system "soil--plant--fertilizer" the time factor shows evolution of the level of soil fertility, which in turn affects the efficiency of the fertilizers applied, that is, the amount of the optimum rates of fertilization and proportions of fertilizers in forecasting.

When fertilizers are regularly applied and yields constantly increase, soils will be more conducive to crop production [9, 11]. This is reflected above all in such indicators of soil fertility as saturation of soils with mobile forms of phosphorus (P_2O_5) and potassium (K_2O), and to some extent in the growth of the content of the organic matter of the soil--humus, the source of easily hydrolyzed nitrogen. As soils become more conducive to

crop production, the range of the allowable concentration of hydrogen ions in the soil solution will become broader, the pH level itself will move toward neutral reaction of the soil medium as a result of liming. In time this process will bring about a situation in which additionally applied phosphorus or potassium fertilizers will not result in a growth of the yield, which indicates adequate saturation of soils with these elements for the nutrition of plants, which under the specific conditions ensure the maximum possible yields of the crop being raised. We can take as an example the level achieved in the conduciveness of soils to crop production in the countries of western Europe (West Germany, Denmark, the Netherlands and Belgium), where phosphorus and potassium fertilizers are not very effective and are applied only in amounts to compensate for the loss of phosphorus and potassium to the harvest and which thereby maintain the level of soil fertility which has been attained [7, 8, 12].

Thus adaptive models of the yield should reflect these tendencies in changing the fertility of soils and the related level of application of various types of fertilizers. This information will be taken into account in calculating optimum rates of fertilizer application and in issuing recommendations for application of fertilizers to the planned yield of agricultural crops.

Conclusions

A computerized system for processing and generalizing the data of field experiments with fertilizers has been developed at VIUA; the system reflects the present level of development of computerized man-machine systems. It constitutes a new step in the development and computerization of mathematical modelbuilding in agricultural-chemical research. The system is intended for building models of the yield of agricultural crops and for calculating from them rates of fertilizer application to obtain the planned yield.

Use of this system makes it possible to speed up the research of agricultural chemistry on the use of fertilizers, to raise its qualitative level and to augment the practical value of recommendations for production.

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